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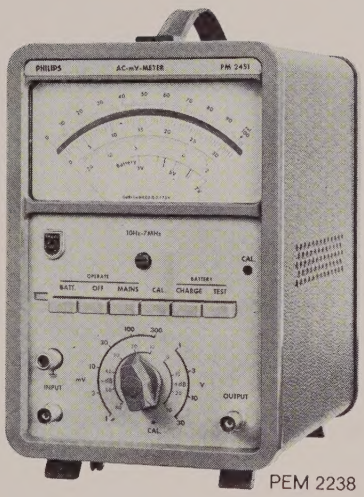


PEM 2238

PHILIPS

Manual

A.C. MILLIVOLTMETER

PM 2451

66 405 00.1-10 1/166/01

IMPORTANT

In correspondence concerning this apparatus, please quote the type number and serial number as given on the type plate at the back of the apparatus.

Contents

GENERAL INFORMATION

I. Introduction 5

II. Block diagram 6

III. Technical Data 8

IV. Accessories 10

DIRECTIONS FOR USE

V. Installation 11
A. Supply 11
B. Earthing 13
C. Battery check 13
D. Charging the rechargeable batteries 14

VI. Operation 15

SERVICE DATA

VII. Circuit description 19
A. Measuring amplifier 19
B. Calibration voltage generator 23
C. Supply 23

VIII. Dismantling the apparatus 27

IX. Maintenance 32

X. Survey of the adjustments 35

XI. Checking and adjusting 36

XII. List of Parts 44
A. Mechanical 44
B. Electrical 47

List of figures

1	Block diagram	6
2	Accessories	10
3	Rear view of the apparatus	12
4	Front view with controls	16
5	Adjusting the measuring probe	17
6	Simplified diagram of the amplifier	20
7	Feed-back circuit of the amplifier	20
8	Simplified diagram of the AC–DC converter	21
9	Cascade stage	22
10	Location of the print-plates	26
11	Bottom view	28
12	Exploded view of the measuring probe	29
13	Cross section of the measuring probe	30
14	Left-side view	33
15	Right-side view	34
16	Collector voltage, TS404	39
17	Collector voltage, TS501	39
18	Front view with item numbers	46
19	Interior view from the rear	52
20	Top view	53
21	Print-plate U2	54
22	Print-plate U3	55
23	Print-plate U4	56
24	Print-plate U5	57
25	Print-plate U6	58
26	Push-button switch SK2	59
27	Switch SK101	60
28	Transformer T1	61
29	Transformer T501	62
30	Transformer T502	62
31	Circuit diagram, PM 2451	65

GENERAL INFORMATION

Introduction

The PHILIPS amplifier Voltmeter PM 2451 is a fully transistorised instrument for measuring voltages from 50 μV up to 300 V, in the frequency range of 10 c/s – 7 Mc/s.

Power supply may be effected:

- from the mains.
- by means of rechargeable batteries.
- by means of dry-cell batteries.

Due to the above, and to its large band-width and high sensitivity, the apparatus is suited for a wide range of applications in the field of electronics.
It can, for instance, be used for measurements in the video-frequency range, in AF techniques, in carrier-wave telephony and electro-acoustics as well as for measuring transducers and measuring transformers.
The apparatus is highly responsive, has a large temperature stability and a very short heating-up time.
The absence of hum in case of battery supply and the low signal to noise ratio make the apparatus extremely suitable for use as wide-band amplifier. With aid of the attenuator probe the input impedance may be increased from 1 MΩ//30 pF up to 10 MΩ//8 pF.
The accessory measuring clips, hooks and plugs facilitate connection of the apparatus to the circuit under test.
The large, efficient mirror scales, which have been calibrated in the r.m.s. value of sine-wave voltages, ensure an easy and accurate reading.
The rechargeable batteries can be charged in approximately 14 hours with the incorporated battery charger, also during measurements.

Block diagram

II

The measuring voltage on socket "INPUT" is applied to the input attenuator. This is a capacitively compensated and fully screened voltage divider with a ratio of 1 : 1 or 100 : 1. The output of the attenuator is connected to the input of the impedance transformer, which consists of a field effect transistor and an emitter-follower. The following main attenuator is an ohmic voltage divider with steps of 10 dB and ensures a constant "source" impedance for the pre-amplifier. The latter consists of two amplifier stages, coupled via an emitter-follower.

A separator stage prevents feed-back from the output of the amplifier to the following rectifier circuit. This rectifier circuit delivers a current through the measuring instrument, which is proportional to the average value of the input voltage. The rectifier is basically identical to the pre-amplifier. The measuring instrument, together with the rectifier circuit, is included in a feed-back circuit.

In position "CAL." of the range selector, a 100 mV, 10 kc/s voltage delivered by an internal calibration voltage generator, is applied to the input attenuator. The apparatus may then be calibrated. The calibration voltage generator is only operative when button "CAL." is depressed..

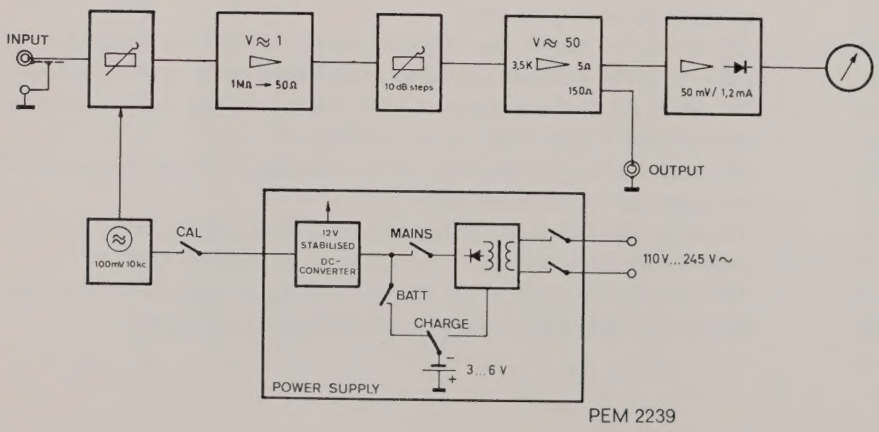


Fig. 1. Block diagram

The supply of the apparatus may be effected from the mains, dry-cell batteries or rechargeable batteries. Selection is effected with the aid of push-buttons. A d.c. voltage converter transforms the d.c. supply voltage into the desired stable 12-V voltage, which serves for supplying the measuring amplifier and the calibration-voltage generator. Locking circuits prevent measuring errors in case of faulty operation.

Technical data

III

Properties expressed in numerical values with tolerances stated are guaranteed by the manufacturer. Numerical values without tolerances serve merely for information and indicate the properties of an average apparatus.

Measuring ranges

Direct: 10 ranges
1 mV–30 V (full-scale values)
With attenuator probe 10 : 1
10 mV–300 V (full-scale values)

Frequency range

10 c/s ... 7 Mc/s

Input impedance

Direct : 1 MΩ//30 pF
With probe: 10 : 1 10 mΩ//8 pF

Accuracy

Maximum measuring error ± 2% of full-scale value at:
- nominal mains voltage ± 10% or a battery voltage from 3–7 V
- frequency 10 kc/s
- sine-wave signal
- after internal calibration
- ambient temperature 10° ... 35° C

Influence of frequency and temperature variations

Frequency	*10 ... 35° C*	*0 ... 45° C (additional error)*
40 c/s ... 2 Mc/s	± 1%	1%
10 c/s ... 3 Mc/s	± 2%	1%
3 Mc/s ... 5 Mc/s	± 4%	2%
5 Mc/s ... 7 Mc/s	± 5%	2%*)

For ambient temperatures above 35° C, the specifications apply only for battery supply.

*) *Additional linearity error —1% f.s.d.*

Preliminary deflection	With open-circuited input : < 30 μV With short-circuited input : < 20 μV
Amplifier output	50 mV at full-scale deflection "Source" resistance: 150 Ω Noise voltage with respect to the input: 40 μV (open-circuited input)
Maximum permissible d.c. voltage	400 V in all ranges
Maximum deviation attenuator	± 1%
Supply	mains voltage: 110, 125, 145, 200, 220, 245 V ±10%, 50–400 c/s batteries: 4 dry cells, 1.5 V or 4 nickel cadmium or steel rechargeable batteries (dimensions approx. 32 mm diam. × 60 mm) charging time: approx. 14 hours charging current: approx. 250 mA
Current consumption	at 3–V battery voltage: approx. 100 mA d.c. at 6–V battery voltage: approx. 50 mA d.c. with mains supply, nominal voltage 220 V: approx. 35 mA a.c.
Operating time	Per charging, or per set of dry-cell batteries: 40 ... 200 hours (dependent of use, continuous or interrupted)
Mechanical Data	Height 250 mm Width 157 mm Depth 230 mm Weight 4.3 kg (without batteries)

Accessories

IV

Mains cord

Measuring cable

Measuring probe with measuring plug, measuring hook and measuring clip.

Attenuator probe 10 : 1 with measuring plug, measuring hook and measuring clip.

Adapter plug (BNC → 4 mm sockets)

1 Spare fuse 63 mA

2 Spare fuses 125 mA

Manual

Fig. 2. Accessories

DIRECTIONS FOR USE

Installation

A. SUPPLY

1. Connection to the mains

If required, the voltage adapter at the rear of the apparatus should be adjusted to the local mains voltage. For this, remove the cover plate (see Fig. 3), pull out the adapter, turn it until the desired voltage value is uppermost and depress the adapter again.
The current value of the fuse is 63 mA (delayed-action) for 200–245 V and 125 mA (delayed-action) for 110–145 V mains.

2. Supply from dry-cells or rechargeable batteries

Supply of the apparatus may be effected from 4 dry-cells ("D" Mono-cells), NiCd or steel rechargeable batteries, which may have the following dimensions:

- Diameter 30–34 mm
- Length (without central contact cap) 54–59.5 mm

Fitting the dry-cells or rechargeable batteries:

- Push up slide locks S (see Fig. 3)
- Open the battery compartment, by removing the relevant lid
- **Remove the insulation disc, which is found in the lower battery compartment!**
  This disc may be used to prevent accidental switching on of the apparatus during transportation of a voltmeter in which the batteries have already been fitted.
- Place the dry-cell or rechargeable batteries into the compartments in such a way that in each compartment the positive pole (contact cap) faces inwards in the left-hand compartment and outwards in the right-hand compartment.

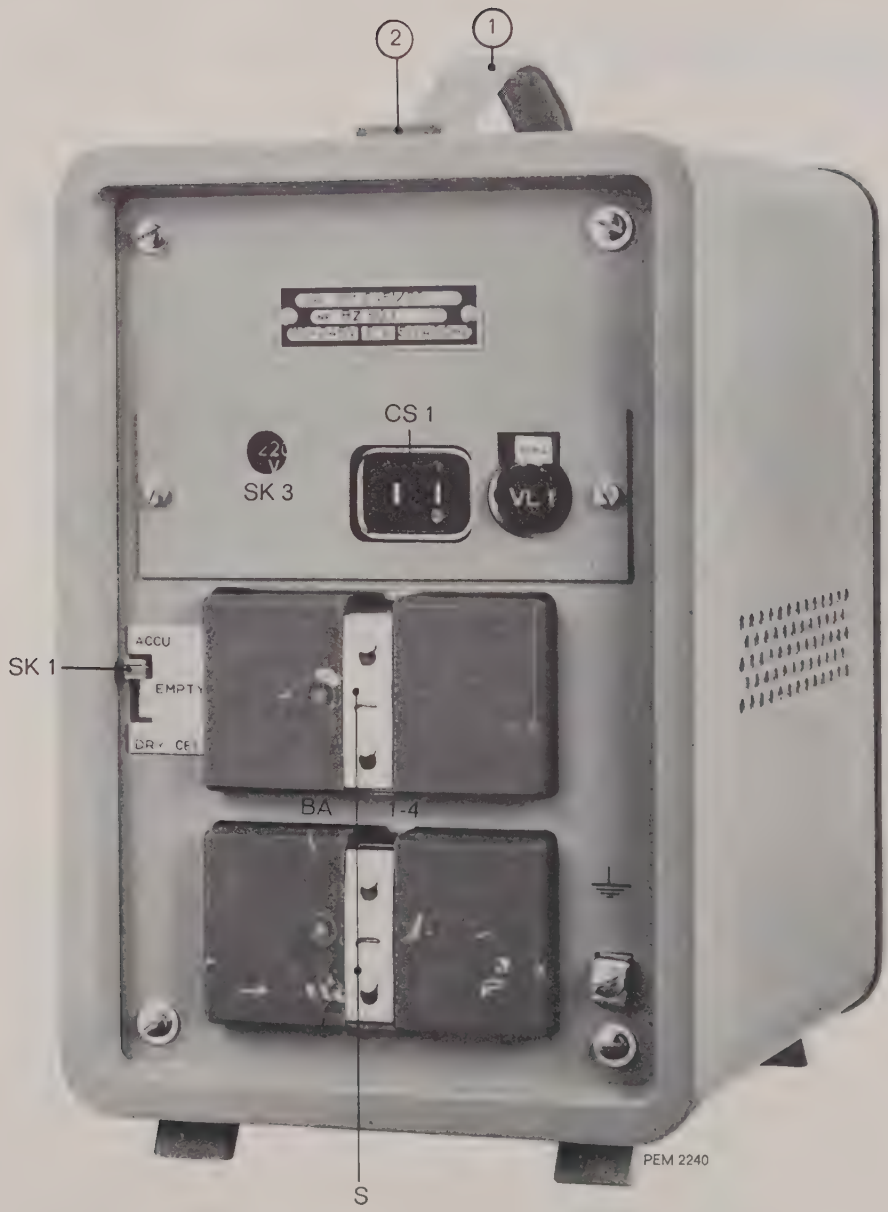


Fig. 3. Rear view of the apparatus

When the batteries are inserted incorrectly, the battery compartments cannot be closed.
Moreover, make sure that the insulation disc against the bottom of some types of batteries are removed.

If the cap of the positive pole has a soldering tag, this should be cut off.

Slide switch "ACCU – EMPTY-DRY-CELLS" (see Fig. 3)
Meaning of the indications:
ACCU – rechargeable batteries
EMPTY – empty (no cells)
DRY CELLS – dry cell batteries
This switch, which is located at the rear of the apparatus, should be placed in the position corresponding to the operating condition.

B. EARTHING

The apparatus may be earthed in the following ways:
- Via the measuring cable or via the measuring probe when the circuit under test has already been connected to earth.
- Via the mains cord, if the latter is connected to a wall socket with rim-earthing contacts
- Via the earthing screw "⏚" at the rear of the apparatus (see Fig. 3).
- Via the earthing socket "⏚" at the front of the apparatus (see Fig. 4).

C. BATTERY CHECK

In order to check the cell voltage or the voltage of the rechargeable batteries, button "BATTERY TEST" should be depressed.
The measuring instrument indicates the supply voltage, independent of the position of the range selector.
When using dry-cell batteries the instrument should indicate a voltage of at least 3 V.
The measuring apparatus can only be used up to a battery voltage of 3 V without the tolerances specified in the Technical Data being affected. The standard dry-cell batteries can therefore be almost completely used up. When fully charged rechargeable batteries are used, the voltage is about 5 V. If the voltage is less than 4.4 V (bottom red line) the rechargeable batteries should be charged, as a lower voltage usually is not permissible for the cells used.

D. CHARGING THE RECHARGEABLE BATTERIES

For charging the batteries the apparatus should be connected to the a.c. mains and button "CHARGE" should be depressed; the slide switch at the rear of the apparatus should be set to position "ACCU". The charging condition of the cells can be checked by depressing button "TEST" during the charging process.

The rechargeable batteries may be charged up to maximum 5.9 V (upper red mark on the meter scale), which is obtained after a charging time of approximately 14 hours.

The charging current is 250 mA at a nominal mains voltage.

It is recommended to check whether this charging current is permissible for the batteries used.

Operation

VI

Switching on

The apparatus is switched on when:

a. Button "BATT." is depressed. Then the apparatus is supplied by dry-cells or rechargeable batteries.

b. Button "MAINS" is depressed. The apparatus is then supplied from the mains.

A red indication on the left of the push-button switch shows that the apparatus is switched on.

With button "OFF" the apparatus may be switched off in both cases.

Calibration

With the aid of an internal calibration voltage generator, which delivers a calibration voltage of 100 mV, 10 kc/s, it is possible to calibrate the measuring instrument.

1. Place the apparatus on a horizontal surface and check that the mechanical zero setting is correct (apparatus switched off). If necessary, adjust exactly to zero with aid of the correction screw.
2. – Switch the apparatus on with the aid of button "MAINS" or "BATT".
   – Depress button "CAL.".
   – Set the range selector to "CAL.".
   – After one minute (to obtain the required stability of the calibration voltage generator) check if the pointer is at 100 (point cal.).
   – In case of a deviation, adjust exactly to 100 with the aid of correction screw "CAL".

Voltage measurement

The voltage to be measured is directly applied via the coaxial measuring cable to socket "INPUT" up to values of maximum 30 V (Ri = 1 MΩ). For higher voltages use the attenuator probe, by means of which measurements of up to maximum 300 V are possible (Ri = 10 MΩ).

When using the adapter plug (BNC connector/4-mm sockets), ensure that non-screened connections are not influenced by stray fields, which may give rise to measuring errors.

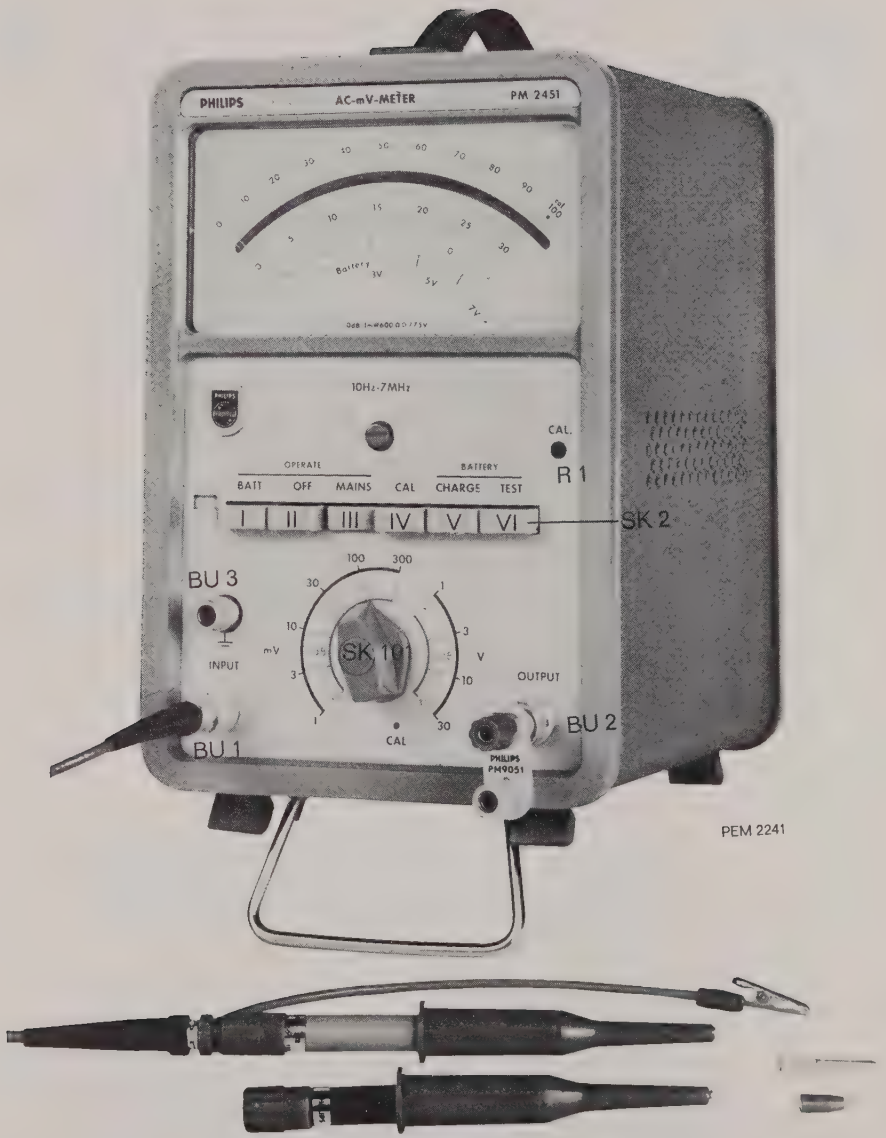


Fig. 4. Front view

With all measurements, ensure that a proper and direct earthing connection to the measuring object has been provided (avoid double earthing). For checking the voltage waveform, a cathode-ray oscilloscope may be connected to socket "OUTPUT".

Attenuator probe

If the measuring probe is incorrectly adjusted, the frequency of the voltage to be measured may affect the measuring accuracy (see chapter XI "Checking and Adjusting", point 7f).
An easy way of checking this is to apply a voltage of, for instance, 300 mV (100 kc/s) directly to the apparatus. The same voltage should then be applied via the attenuator probe and the range selector should be set to 30 mV. The probe capacitance should be adjusted so that the measuring instrument indicates exactly 30 mV.
Adjustment (see Fig. 5):

- Loosen ring "2" while holding sleeve "1".
- Hold nut "1" and adjust probe "3".
- Tighten ring "2".

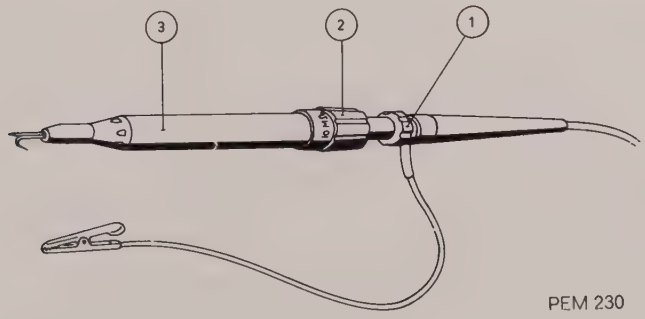


Fig. 5. Adjusting the measuring probe

Amplifier

The amplifier of the measuring apparatus can be employed as a linear amplifier for every arbitrary purpose in the frequency range from 10 c/s up to 7 Mc/s.

The amplification factor in the 1–mV range is approximately 50. On socket "OUTPUT" a voltage of approx. 50 mV is present at an output resistance of 150 Ω, independent of the measuring range.

The feed-back of the external load on the measuring instrument is very slight. On socket "OUTPUT", voltages of up to maximum 150 mVp may occur without non-linear distortion.

Due to the low noise voltage ($\leq$ 40 μV) the amplifier is, for instance, suitable for increasing the sensitivity of 10 Mc/s oscilloscopes from 50 mV/cm up to 1 mV/cm.

The noise voltage may still further be reduced by limiting the band-width of the frequency range.

SERVICE DATA

Circuit description

VII

A. MEASURING AMPLIFIER

1. Input (U1)

The measuring voltage on BU1 is applied to impedance transformer stage U2 via:

- SK101/I/II and R122 (direct input) or
- SK101/I, R101–R102–C102–C103, SK101/II and R122 (via the high-ohmic, frequency-independent 100 : 1 attenuator).

The input capacitance in both cases is equalised with C101, so that the measuring probe can be used in every measuring range.
R123 serves for damping the parasitic oscillations in the circuit formed by C103 and the self-inductance of the wiring.

2. Impedance transformer circuit (U2)

This circuit consists of field effect transistor TS201 and emitter-follower TS202. Their biasing is determined by adjusting range R204. The current through protection diodes GR201, GR202 and GR203 is limited by R122, R202, R201. R201//C202 improve the frequency response curve. R209 damps the parallel circuit formed by C204 and the self-inductance of C205, whereas C204//C205 prevents feed-back via the supply lines.
In the following voltage divider (U1), the measuring voltage is attenuated in steps of 10 dB, while R112 ... R121 ensure that the "source" resistance for the following amplifier (U3) remains constant in all measuring ranges.
To prevent induction of interference signals in the resistors which are not switched in, these have been earthed at both ends.

3. Amplifier (U3)

This amplifier consists of the emitter-followers TS301 and TS303, feed-back stage TS302, amplifier TS304 and divider stage TS305.
A feed-back network consisting of three tappings, is connected to the emitter of TS302 and consequently has a low-ohmic connection to earth

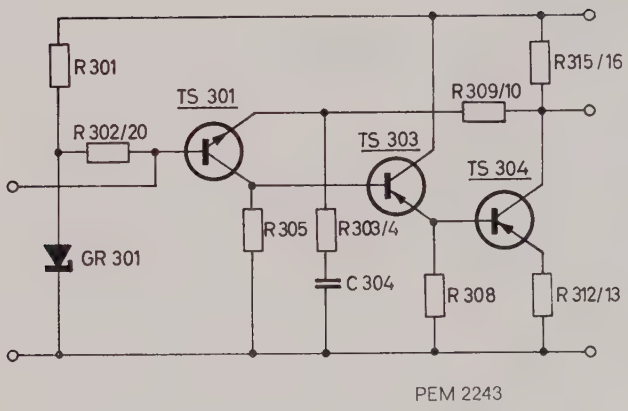


Fig. 6. Simplified diagram of the amplifier

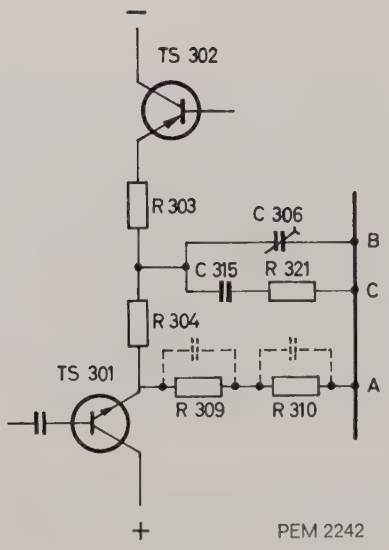


Fig. 7. Feed-back circuit of the amplifier

(see Fig. 7). Possible interference voltages via the supply circuit consequently have no influence.

The resistors R309, R310, R304 and R303 form the first feed-back tapping A.

To reduce parasitic capacitance, R309 and R310 have been connected in series. Tapping B, consisting of C306 and C304 forms a correction circuit for high frequencies and tapping C, consisting of R321, C315 and R304 for the low frequencies.

The lowest part of the frequency response curve is slightly boosted by the variable load R302, R320 and C302. This circuit also suppresses the noise of GR301.

The upper limit of the frequency response curve is determined by C303-L301 and C307-L302; as a result of this, the circuit is not affected by possible variations in the h.f. parameters of the transistors employed. The divider stage TS305 forms a very low "source" impedance for the following a.c./d.c. converter as well as for output socket BU2. C311–R318 correct the frequency response curve, because the high frequencies slightly benefit from the a.c./d.c. converter. C312 and C313 decouple a part of the emitter resistance of TS305. C314 decouples the power supply circuit.

4. AC/DC Converter (U4)

This converter comprises amplifier stages TS401 and TS403, which are coupled by emitter follower TS402 (see Fig. 8).

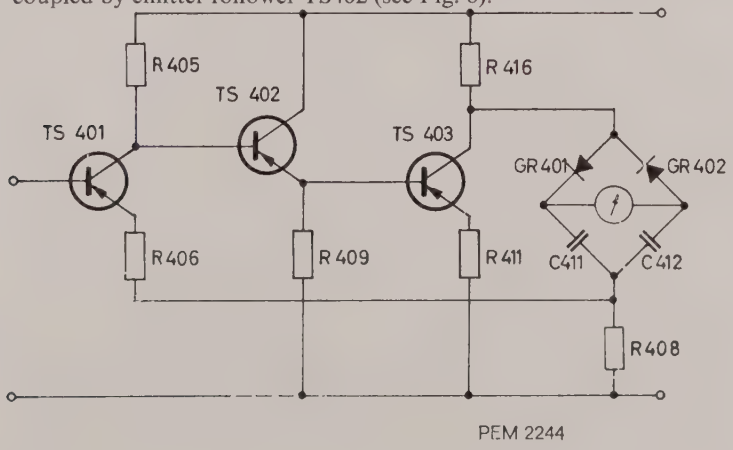


Fig. 8. Simplified circuit diagram of the AC/DC converter

The measuring instrument together with the rectifier circuit, has been included in the feed-back circuit.
The third stage (TS403) has been extended to a cascade circuit by means of TS404 (see Fig. 9), in order to avoid an amplification factor which should be dependent on the supplied voltage. Otherwise the measuring instrument and the rectifier circuit would form a part of the collector impedance of TS403.
The working point of TS404 can be adjusted with adjusting range R422. Via R401 and R410, d.c. feed-back from the emitter of TS403 to the base of TS401 occurs. For the higher frequencies, feed-back is obtained via the capacitances of GR401 and GR402, which however is compensated for by R403, C405 and C406.
R402 and C404 prevent possible oscillations.
GR404 prevents working-point shift in case of over-modulation and ensures a short recovery time of the measuring instrument after being overloaded.
GR403 protects the instrument against overload.
Temperature compensation is obtained by the damped oscillatory circuit C416–L401, which is effected by R425 depending upon the temperature.
H.F. feed-back on the supply will be suppressed by the filter with C415, while R426 damps oscillations. By means of R1, the indication of the measuring instrument is adjusted, whereby R418 and R419 guarantee a nearly linear function of this potentiometer.

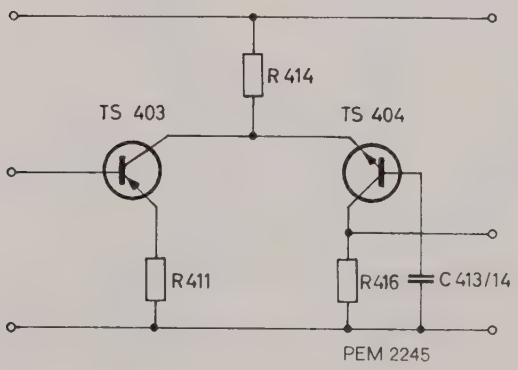


Fig. 9. Cascade Circuit

B. CALIBRATION-VOLTAGE GENERATOR (U5)

With normal use of the apparatus, this circuit is switched off (Button "CAL.", SK2/IV).
This generator comprises an LC oscillator (TS503, T501 and C506) and delivers a sine-wave voltage of 10 kc/s.
This voltage is stabilized as follows:
When the peak value of the voltage across S4 of T501 becomes higher (more positive) than the reference voltage across GR503, a signal will be applied to amplifier TS501 during these peaks via C501.
The signal is subsequently full-wave rectified by TS501 and GR501 and further amplified by TS502. Thus a control voltage is obtained across C504 which influences the biasing of TS503. The voltage across S4 is adjusted so, that the average value of the 10 kc/s voltage is slightly higher than the reference voltage. The calibration voltage is adjusted to exactly 100 mV with R515 and R516.
GR502 and GR504 serve for temperature compensation.

C. SUPPLY

1. Mains section (U6)

Via the full-wave rectifier circuit GR601-GR602 a 18–V voltage arises across C601.
This high value, as compared with the battery voltage (3 ... 6 V), is required to obtain the correct charging current (250 mA) for the rechargeable batteries BA1 $\overline{\bullet}$ 4.
In position "MAINS" of SK2, GR1 ensures that the d.c. voltage converter (U5) receives a –5.8 V voltage, while GR2 limits the output voltage of U6 to –7.7 V.

2. Direct voltage converter (U5)

a. Function of the blocking transformer

Because in position "BATT" of SK2 the apparatus is supplied by a voltage which may have any value between 3 and 6 V, this circuit ensures matching of the voltage to the desired stable 12–V supply voltage; thereby the power consumption remains approximately proportional to the power output (efficiency 65–75%).
The following description of the operating principle refers to one cycle of the oscillator.
Assume that the collector-emitter transition of TS506 is conductive. The

battery voltage is then almost entirely present across winding S1 of T502. As long as the voltage is constant, the current through coil S1 of T502 will increase linearly ($i = U/L \cdot t$). The collector-emitter voltage of TS506 remains below the knee voltage of the transistor, which will be determined by the base current. The current through the transistor remains constant practically until the knee voltage will be attained. The voltage increases fast via the collector-emitter transition. As a result of this, the voltage across winding S1 decreases. This voltage variation will be transferred on winding S2, so that transistor TS506 becomes non-conductive. Due to the large current variation a large voltage transient appears in the transformer, so that capacitor C510 will be charged via GR508. When the magnetic energy in the transformer is eliminated, diode GR508 will be blocked.

The transformer produces decay phenomena via the capacitances of the transistor and the parasitic capacitances. In winding S2, voltage pulses occur which make TS506 conductive again, so that the oscillation process is started anew.

When after a few cycles, a voltage of approx. 12 V is obtained across C508 and C512, the diodes GR505 and GR506 become conductive again and TS504 and TS505 become non-conductive.

Diode GR508 ensures that the current can only flow in the charging direction. GR507 and R522 have been provided to ensure that the electrolytic capacitors are charged fast at the moment of switching on.

The power transferred is proportional to the magnetic energy in the transformer at the moment of change-over, i.e., it is proportional to the maximum collector current. Thus the power may be controlled by the base current of the transistor.

b. Control-circuit of the stabilization

On the output, parallel to C508 and C512, the voltage is controlled by a bridge circuit GR506/R520. The reference voltage is formed by the sum of the Zener voltages of GR505 and GR506. When the output voltage across C508/C512 exceeds the reference voltage, the collector current of TS504 decreases.

Consequently, TS505 is recontrolled which effects a decrease of the average base current of TS506, i.e. the base receives a higher positive biasing voltage.

As the oscillation frequency of TS506 at a small base current will be lower than at a larger base current, the electrolytic capacitors C510/C508/C512

will be charged less, so that the output voltage remains virtually the same as the reference voltage.
At a higher current consumption or at a lower battery voltage, the oscillation frequency is higher than at a small load current or with good batteries. Load variations are thus also compensated for as well as mains voltage variations in case of supply from the mains. By means of this circuit, an excellent stability of the supply voltage is obtained. Moreover, it is possible to obtain optimum battery efficiency at a minimum influence of the measuring accuracy of the apparatus.

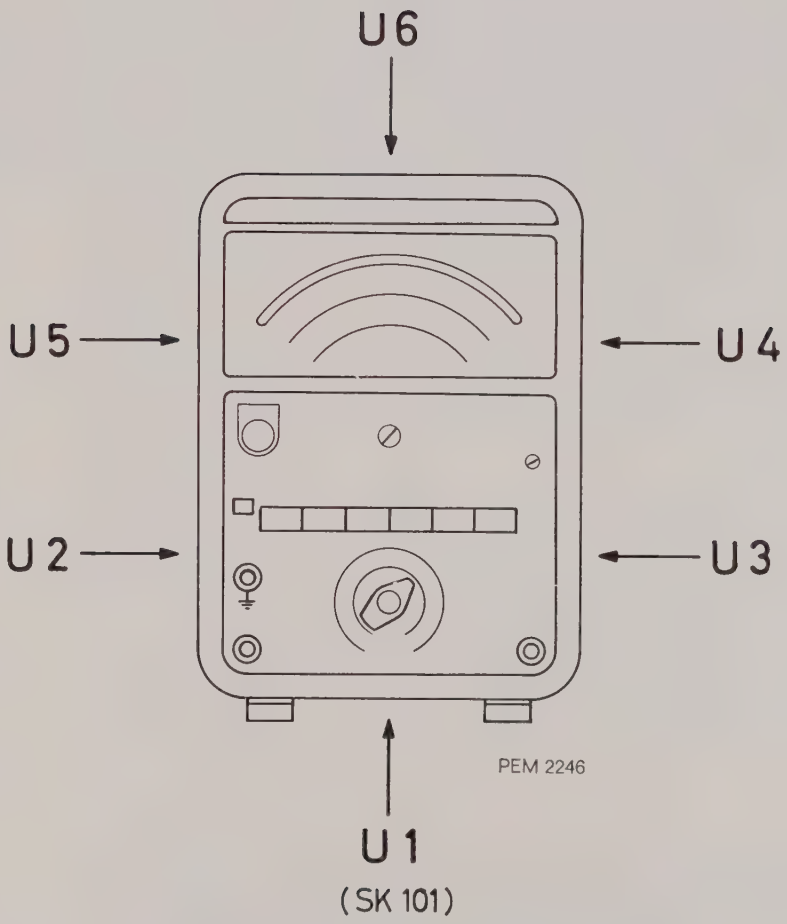


Fig. 10. Location of the print-plates

Dismantling the apparatus

1. Removing the cabinet

- Remove the four screws in the corners of the rear panel
- Detach the rear panel
- Slide the cabinet off the frame.

2. Print-plates (see Fig. 10)

All print-plates can easily be removed after loosening the fixing screws. Print-plate U6, which is located in the middle of the apparatus, can be detached by unscrewing the two screws from the fixing brackets and by pressing the brackets apart.

3. Attenuator switch

- Remove the cover plate.
- Unsolder all wires coming from the switch.
- Remove the control knob.
- Remove the central retaining nut.
- Remove the battery compartment, which is located behind the switch.
- Remove the four fixing screws from the intermediate screening plate.
- The complete attenuator switch can then be taken out of the apparatus.

4. Measuring instrument

- Unsolder the connection wires coming from the instrument.
- Remove the screws from the transverse profile.
- Detach the instrument.

5. Text plate

- Remove the knob of the range selector.
- Remove the 6 screws from the front edge.
- Remove this front edge.
- Remove the text plate.

6. Push-button switch

- Remove the two fixing screws of the push-button switch.
- Unsolder the connection wires.
- Detach the push-button switch.

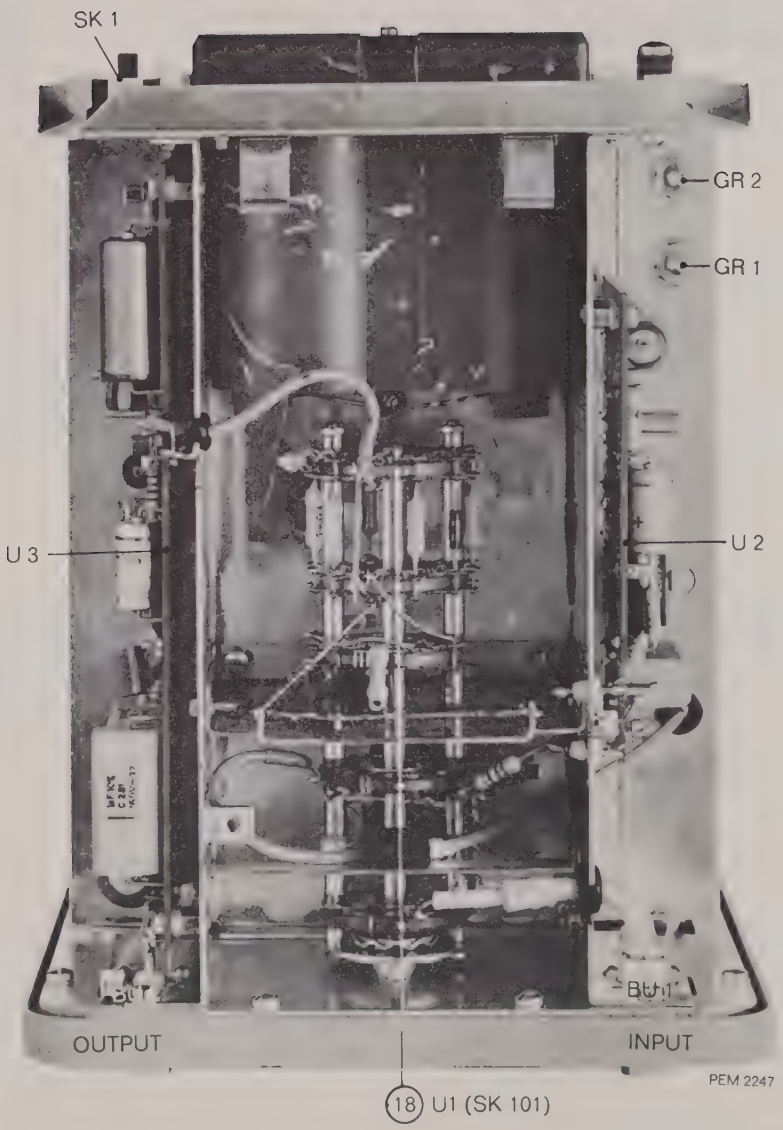


Fig. 11. Bottom view

7. BNC sockets

- Unsolder the connection cable from the socket.
- Unscrew the BNC socket.
- Remove the front edge and the text plate (point 5).
- Detach the socket.

8. Dismantling of the attenuator probe (see Fig. 12)

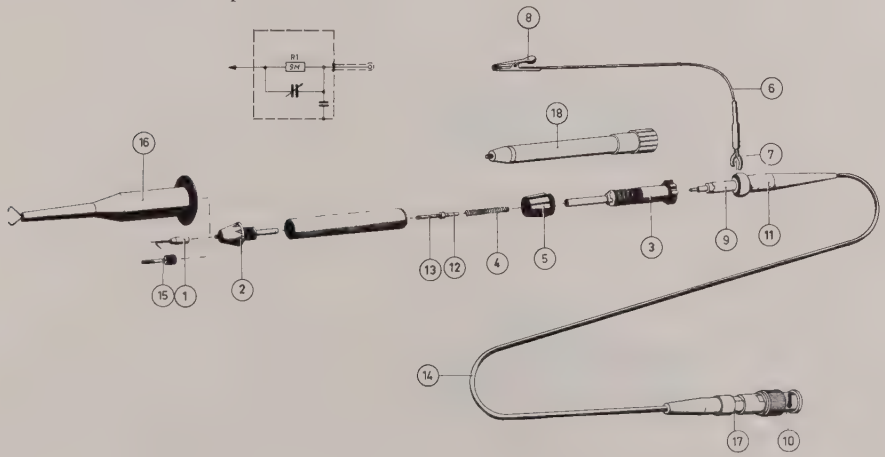
- Remove the earthing wire.
- Unscrew measuring hook "1" and stator "2".
- The resistor with socket "12" and pressure spring "4" can then be removed.
- Unscrew rotor "3".
- Remove adjusting nut "5".
- Remove the probe cable from rotor "3".

9. Replacing the measuring probe cable (see Fig. 13)

The attenuator probe has been provided with a special coaxial cable. In case of replacement proceed as follows:

a. On the probe side.

- Slide cable grommet "a" from "b".
- Remove pin "c".



PEM 1160

Fig. 12. Exploded view of the measuring probe

- Heat the solder point "d" and at the same time push out bushing "b", so that this assembly is slid off the cable.
- Remove outer jacket "e" from the new cable over a length of 32 mm.
- Remove the screening jacket "f" over a length of 27 mm.
- Remove core insulation "g" over a length of 15 mm.
- Bushing "b" is slid over the cable until it reaches the core insulation. The cable core then protrudes from the aperture at the front side.
- Replace pin "c" in the aperture at the front.
  Consequently, the cable core is fixed.
- Cut the protruding part off the cable core and the pin at approx. 1 mm from the plug.
- Solder screening jacket "f" to bushing "b".
- Slid cable grommet "a" again over bushing "b".
- Fit the measuring probe and refit the earthing wire.

b. On the side of the BNC connector

- Remove pin "c".
- Remove grommet "h".
- Heat up solder point "i" and pull the cable from nut "k".
- Remove outer jacket "l" of the new cable over a length of 35 mm, screening "m" over a length of 29 mm and the inner insulation over a length of 10 mm.

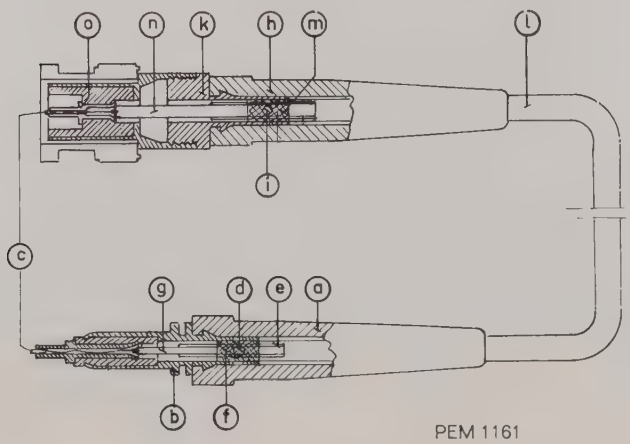


Fig. 13. Cross section of the measuring probe

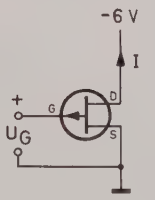
- Slide the cable into the BNC connector until core "n" touches contact pin "o".
- The wire then protrudes from the contact pin.
- Secure the wire by refitting the pin into the contact pin.
- Cut off the protruding part from the pin.
- Solder the screening "m" onto points "i".
- Slip the cable grommet again over the cable.

10. Replacing electrical components

When replacing electrical components as capacitors, resistors, diodes, transistors, etc. use the values given in the circuit diagram (Fig. 31) or in the list of electrical parts.
The field effect transistor TS201 and the Zener diode GR503 however should be selected. Should one of these semi-conductors be replaced, carry out the following check:

TS201 (2N2386)

Adjust the voltage U_G so, that I = 0.8 mA. U_G should have a value between + 0.3 V and + 3.6 V d.c.



GR503 (BZY61)

Control a directed current of 2.5 mA through the diode. Measure the voltage U at a temperature of 25 °C and 50 °C. Admissible temperature-coefficient + 3 ... + 5mV/°C.

Remark

In case of breakdowns one can always apply to the world-wide PHILIPS Service Organization.
Whenever it is desired to send the apparatus to a PHILIPS Service Centre for repair, the following points should be observed:
- *tie on a label, bearing full name and address of the sender.*
- *indicate as complete as possible the symptom(s) of the fault(s).*
- *carefully pack the apparatus in the original packing, or, if no longer available, in a wooden crate.*
- *send the apparatus to the address provided by your local PHILIPS representative.*

Maintenance

IX

In general, the apparatus hardly requires any maintenance, as it does not contain any components which are actually subject to wear.
However, in view of reliability of operation the apparatus should not be exposed to excessive heat or moisture.
When the apparatus is not in use for a prolonged period the batteries, if any, should be removed from the battery compartments.

a. Measuring-range selector

If necessary the spindle of the switch should be lightly lubricated at the bearing points with thin liquid oil. The stop should be greased with Molykote grease.

b. Push-button switch

The switching mechanism may be lightly lubricated with thin liquid oil.

c. Switch contacts

In case of possible contact interference the switch contacts may only be treated with special switch oil. (The code number of this oil is stated in the list of Mechanical Parts).

d. Cabinet

The cabinet consists of aluminium, coated with a P.V.C. layer. After removal from the apparatus the cabinet may be cleaned with water and soap.

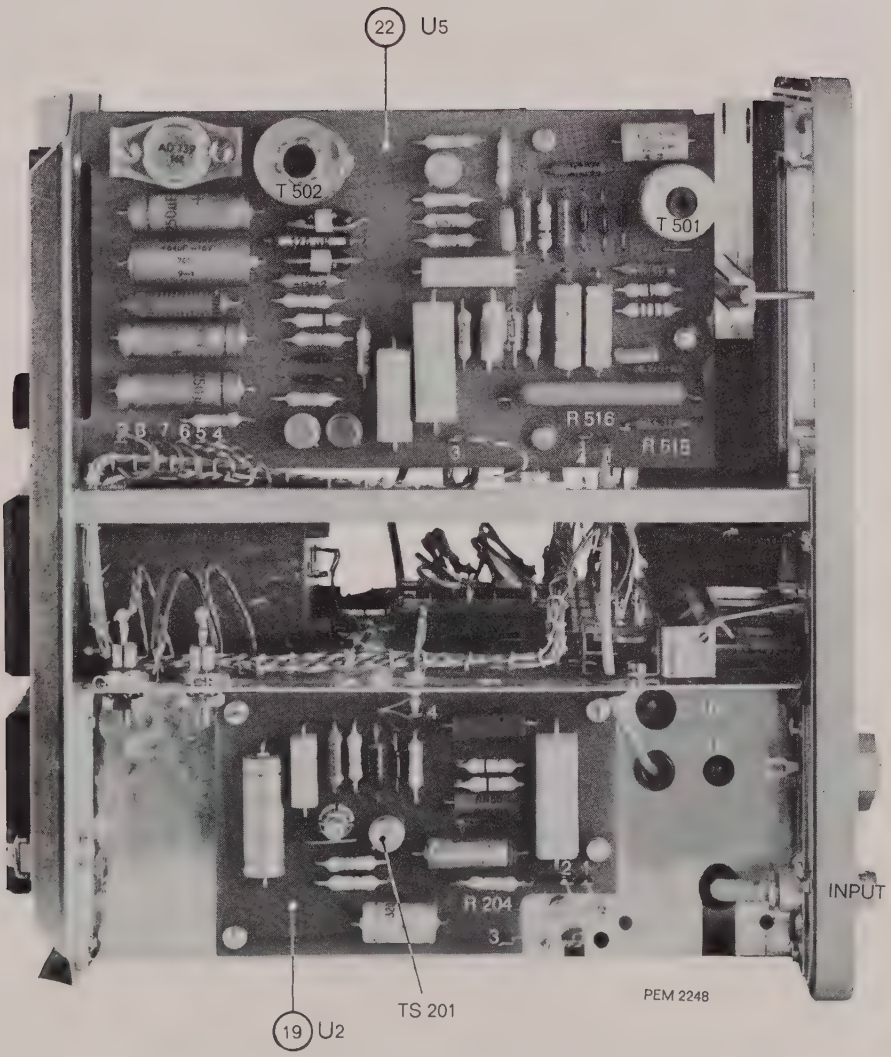


Fig. 14. Left-side view

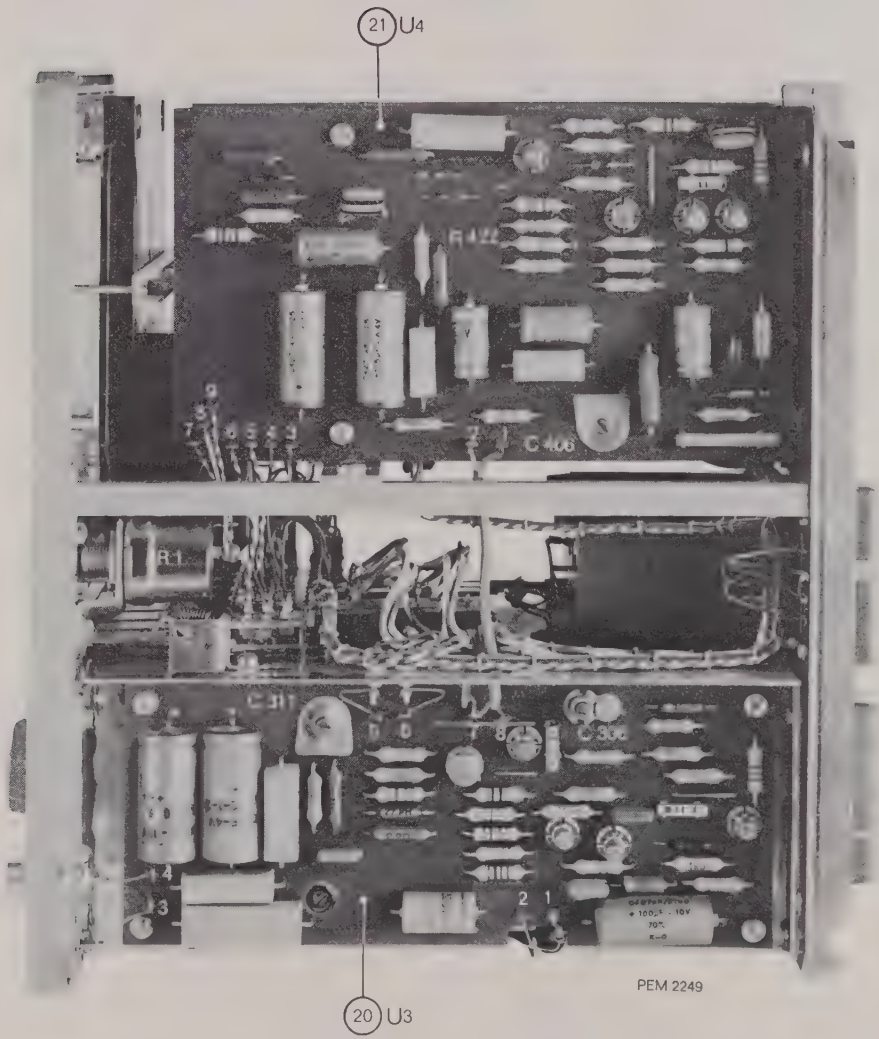


Fig. 15. Right-side view

Survey of the adjustments

Checking and adjusting is effected according to the instructions given in chapter XI "Checking and Adjusting".
For a complete or an extensive adjustment check of the apparatus, it is preferable to follow the sequence given in chapter XI.

Adjusting element	*Fig.*	*Adjustment or setting*	*Required measuring or auxiliary equipment*	*Adjustment according to chapter*
R1	4 + 15	Calibration of the measuring instrument		VI
R204	14 + 21	Working point TS201	Voltmeter (for instance, P 81700)	XI. 3a
R422	15 + 23	Working point TS404	Voltmeter (for instance, P 81700)	XI. 3a
R515/R516	14 + 24	Calibration voltage	LF generator; precision LF millivoltmeter	XI. 11
C101/C102	14	Frequency-dependent voltage divider	LF generator; precision LF millivoltmeter	XI. 7e, g
C306/C311/C406	15 + 22 + 23	HF adjustment frequency range	HF generator; precision HF millivoltmeter	XI. 7b, c, d
C		Measuring probe capacitance	LF generator; LF millivoltmeter	V. D or XI. 7 f

Checking and adjusting

The tolerances mentioned in this chapter are factory tolerances which only apply when the apparatus is readjusted. These may differ from the data given in chapter III "Technical Data".
Recalibration according to the checks given under points 4–11 may only be effected when measuring equipment and voltage sources are available, which meet the relevant requirements.

1. Mechanical zero setting, voltage adapter, fuse

- With the apparatus switched off, check if the mechanical zero setting of the meter pointer is correct. Deviations may be corrected with the correction screw.
  The apparatus should be in the horizontal position during this check.
- The value set by means of the voltage adapter should correspond to the local mains voltage.
- The fuse should have the current value given below:
  for 110 V, 125 V, 145 V : 125 mA delayed-action
  for 200 V, 220 V, 245 V : 63 mA delayed-action

2. Current consumption

- When the apparatus is supplied from the mains, the current consumed can be measured directly in the supply lead (for instance with universal voltmeter P 81700).

Mains voltage (nominal, 50 c/s)	*Buttons "MAINS"* **or** *"CHARGE" depressed*	*Buttons "MAINS"* **and** *"CHARGE" depressed*
110 V	75 mA r.m.s.	90 mA r.m.s.
125 V	65 mA r.m.s.	80 mA r.m.s.
145 V	60 mA r.m.s.	70 mA r.m.s.
200 V	40 mA r.m.s.	50 mA r.m.s.
220 V	40 mA r.m.s.	45 mA r.m.s.
245 V	35 mA r.m.s.	40 mA r.m.s.

For measuring the battery currents one cover should be removed from the battery compartments and a milliammeter should be connected between the then accessible battery connections. Make sure that the batteries make contact with the spring at the bottom of the battery compartment.

Push-button	*Position of SK1*		
	Accu	*Empty*	*Dry cells*
OFF	0	0	0
MAINS	0	0	0
CHARGE	+ 250 mA ± 10%	0	0
MAINS + CHARGE	+ 250 mA ± 10%	0	0
BATT	—50 ... 100 mA*	—50 ... 100 mA*	—50 ... 100 mA*

3. Checking the internal direct and alternating voltages

a. Direct voltages

- For these checking measurements use if possible short measuring cables. Ensure that these cables do not run close to other units of the apparatus, as in case of some measurements (especially measurements 7d, e and f) the current circuits may oscillate. For this reason it is recommended to check this with the aid of an HF oscilloscope, which may be connected to the output of the impedance transformer, the amplifier output or across R408. For the following check, a 10 kc/s alternating voltage is present on these measuring points.
- For effecting the measurements below an arbitrary measuring instrument with a Ri > 100 kΩ may be employed (for instance, P 81700).
- Set the range selector to "CAL." and depress button "CAL.".
- The voltage values given below are measured at the measuring point stated with respect to ⏚ (chassis).

Unit	*Measuring point*	*Value*	*Tolerance*
a. U6	U6/6	—17.8 V	± 1 V
	U6/5	— 5.9 V	± 0.4 V
b. Direct voltage converter U5	U5/8	— 5.9 V	± 0.4 V or V BATT.
	U5/4	—11.8 V	± 0.6 V
c. Calibration oscillator U5	collector TS501	— 7.6 V	± 0.5 V
	emitter TS503	— 1.2 V	± 0.1 V
d. U2	emitter TS202	— 4.7 V	± 0.3 V

* *This current is dependent on the battery voltage.*

Unit	*Measuring point*	*Value*	*Tolerance*
e. U3	U3/8	— 8.3 V	± 0.4 V*
f. U4	emitter TS403	— 4.6 V	± 0.3 V
	collector TS404	— 3.3 V	± 0.2 V**

b. Alternating voltages

- For this measurement, use a calibrated valve voltmeter with a sensitivity of 1 mV and an input impedance of ≥ 1 MΩ//< 100 pF. For checking the voltage to be measured an oscilloscope is recommended, which, for instance, may be connected to the amplifier output of the measuring apparatus employed.
- Set the range selector to "CAL." and depress button "CAL.".
- The voltage values given below have been measured at the test point given with respect to ⏚ (chassis) in r.m.s. values.
- Sensitivity check:
  The meter indication should be adjusted to exactly 100 with the aid of potentiometer "CAL.".

Unit	*Measuring point*	*Value*	*Frequency*
a. U6	U6/6	< 1 V	100 c/s
	U6/5	< 15 mV	100 c/s + a.c. 10 kc/s
b. Direct voltage converter U5	U5/8	< 15 mV	100 c/s + a.c. 10 kc/s
	U5/4	< 2 mV	a.c. 10 kc/s
c. Calibration oscillator U5	collector TS501	(see Fig. 17)	
	collector TS503	3.2 V ± 0.3 V	10 kc/s (sine wave)
	U5/1	0.1 V ± 0.2%	10 kc/s (sine wave)
d. U2	U2/1	0.1 V ± 0.2%	10 kc/s (sine wave)
	U2/3	90 mV ± 5 %	10 kc/s (sine wave)
e. U3	U3/1	88 mV ± 5 %	10 kc/s (sine wave)
	U3/8	48 mV ± 10 %	10 kc/s (sine wave)
	U3/4	50 mV ± 10 %	10 kc/s (sine wave)
f. U4	U4/1	48 mV ± 10 %	10 kc/s (sine wave)
	collector TS404	(see Fig. 16)	
	(measurement only possible with 10 MΩ//10 pF measuring probe)		

* *After replacement of TS201, readjust with R204. The resistance value should lie between 3.9 kΩ and 39 kΩ.*

** *After replacing an element of U4 readjust with R422.*

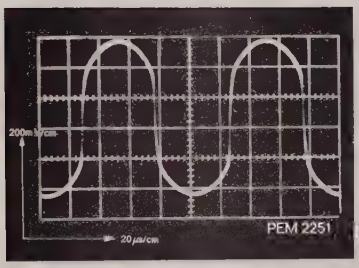


Fig. 16. Collector voltage TS404

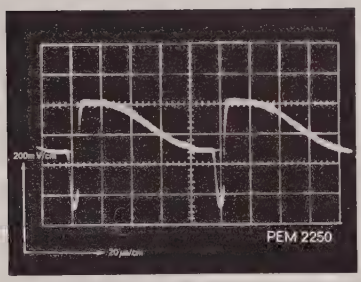


Fig. 17. Collector voltage TS501

4. Control range "CAL." potentiometer

- Button "CAL." released.
- Set the range selector to 100 mV.
- Apply a 50–mV$_{r.m.s.}$, 10 kc/s voltage to the input.
- Turn potentiometer "CAL." counter-clockwise.
  Indication: $\leq$ 47.5 mV
- Turn potentiometer "CAL." clockwise.
  Indication: $\geq$ 52.5 Vm.

5. Linearity of the amplifier.

- Button "CAL." released.
- Set the range selector to 10 mV.
- Apply a voltage of 10 mV$_{r.m.s.}$–10 kc/s.
  Adjust the indication at scale mark 100.
- Set the range selector to 30 mV.
  Indication at scale 30 : 10 $\pm$ 0.4 scale division.
- Set the range selector to 100 mV.
  Indication at 100: 10 $\pm$ 1 scale division.

6. Distortion

- Set the range selector to 300 mV.
- Apply a voltage of 325 mV, 10 kc/s.
- With an oscilloscope check the output voltage.
  (Generator voltage on X–input, amplifier output on Y–input).
  The distortions can be established with aid of the image displayed on the cathode ray tube.

- Increase the applied voltage. Below 350 mV no distortion may be visible (the voltage can be read on the indicating instrument, if the range selector is set to 1 V).
- Requirement: distortion factor d $<$ 1% (at an input voltage of 325 mV).

7. HF adjustment.

- The properties of the measuring equipment used for this adjustment determine the accuracy. A complete readjustment should only be effected when components have been replaced or when the apparatus is obviously detuned.
- Requirements for the auxiliary equipment:
  HF generator : distortion factor $<$ 3%
  HF valve voltmeter : a straight frequency response characteristic $\pm$ max. 0.5%
- During adjustment the cabinet should be removed from the apparatus. After refitting the cabinet the checking measurements should be repeated, and, if necessary, readjustments should be effected.
- For all the supply and measuring cables use coaxial leads. The input voltage is measured directly on the input socket with the aid of a coaxial T connector.
- The following four adjustments a...d should be repeated until the voltages applied give a pointer deflection of 100 $\pm$ 1 scale division at the three frequencies.

Voltage to be applied $\pm$ 0.5%	*Frequency*	*Range*	*Adjust with*	*Adjust to*	*Amplifier output*
a. 100 mV	10 kc/s*	100 mV	R1 (CAL.)	100 scale divisions	make a note of the output voltage
b. 100 mV	6 Mc/s	100 mV	C306	100 scale divisions	—
c. 100 mV	6 Mc/s	100 mV	C311	output voltage obtained under a	—
d. 100 mV	3 Mc/s	100 mV	C406	100 scale divisions	—

* *Select the lowest frequency at which the reference instrument still operates correctly, however, higher than 1 kc/s and lower than 100 kc/s.*

Voltage to be applied ± 0.5%	*Frequency*	*Range*	*Adjust with*	*Adjust to*	*Amplifier output*
e. 316 mV	1 kc/s	300 mV	R1	100 scale divisions	
316 mV	1 kc/s**	1 V	—	—	make a note of the value
316 mV	100 kc/s	300 mV	R1	100 scale divisions	
316 mV	100 kc/s	1 V	C102	value noted	
f. 316 mV	200 c/s	300 mV	R1	100 scale divisions	
316 mV	200 c/s**	30 mV*	—	—	make a note of the value
316 mV	20 kc/s	300 mV	R1	100 scale divisions	
316 mV	20 kc/s	30 mV*	capacitance in the measuring probe	value noted	
g. 3.16 V	200 c/s	300 mV*	R1	100 scale divisions	
3.16 V	200 c/s	1 V*	—	—	make a note of the value
3.16 V	20 kc/s	300 mV*	R1	100 scale divisions	
3.16 V	20 kc/s	1 V*	C101	value noted	

8. Checking measurements (after fitting the cabinet)

Voltage to be applied ± 0.5%	*Frequency*	*Range*	*Indication in scale divisions*	*Amplifier*
100 mV	10 kc/s	100 mV	adjust to 100 ("CAL.")	make a note of value "V"
100 mV	1 Mc/s	100 mV	100 ± 1%	V ± 1%
100 mV	3 Mc/s	100 mV	100 ± 1%	V ± 2%
100 mV	5 Mc/s	100 mV	100 $\left\{ \begin{matrix} +2\% \\ -0\% \end{matrix} \right.$	V ± 3%
100 mV	7 Mc/s	100 mV	97 ± 3%	V $\left\{ \begin{matrix} +0\% \\ -6\% \end{matrix} \right.$
100 mV	10 c/s	100 mV	100 ± 2%	V $\left\{ \begin{matrix} +4\% \\ -0\% \end{matrix} \right.$

Repeat measurements 7e, f and g and if necessary readjust.

---

* *Attenuator probe 10 : 1, 10 MΩ//10 pF connected in series.*

** *This voltage should be exactly equal to the preceding measuring result.*

9. Voltage divider

1st method

Apply the voltages stated below to BU1 and check the meter reading at 1 kc/s and 7 Mc/s.

Voltages to be applied:

at 1 kc/s: 1; 3.16; 10; 31.6; 100; 316 mV ± 0.1 %

at 7 Mc/s: 1; 3.16; 10; 31.6; 100; 316 mV ± 1 %

Reading: value ± 1.5% at 1 kc/s

± 2.5% at 7 Mc/s

2nd method (simplified)

- Set measuring range to 1 mV
- Apply a voltage of 1 kc/s or 7 Mc/s respectively, so that the instrument indicates 100 scale divisions.
- Change over to 3 mV; check indication (10 at scale 30).
- Increase the input voltage until the pointer indicates 100 scale divisions.
- Change over to 10 mV; check indication (10 at scale 30).
- Check all ranges in this way at 1 kc/s and 7 Mc/s.

When using this method, the indication is influenced by the scale linearity. When the indication at 10 (scale 30) indicates the same value or the same deviation for all measurements, the divider is correctly adjusted; the deviation namely refers to the scale linearity.

10. Scale linearity

- Apply the following voltages to BU1:

  100 mV, 60 mV, 30 mV, 20 mV, 10 mV } ± 0.1% at 10 kc/s, ± 0.2% at 5 Mc/s

- Set the range selector to 100 mV.
- Adjust to 100 scale divisions at an input voltage of 100 mV (with the aid of R1, "CAL.").
- For the other voltages the deviation should not exceed 1 % of full scale value.
- Check at 10 kc/s and 5 Mc/s.

11. Calibration voltage oscillator

- Apply a 100 mV ± 0.1%, 10 kc/s voltage to BU1.
- Set the range selector to 100 mV.
- Adjust the pointer to exactly 100 with aid of potentiometer R1 (CAL.)
- Depress button "CAL.".
- Set the range selector to "CAL.".
- Connect U5/1 and connection point R515/C507 to a resistance box. (Remove or disconnect resistors R515 and R516).
- With aid of the resistance box determine the resistance value at which the instrument indicates 100 mV ± 0.1%.
- Include resistors of the value found for R516 (coarse adjustment) and R515 (fine adjustment) in the circuit.
- Final check: indication 100 mV ± 0.1%.

List of parts

XII

A. MECHANICAL

Item	*Fig.*	*Quantity*	*Code number*	*Description*	
1	3	1	M7 076 25	Handle	**
2	3	2	P4 655 89	Bracket	**
3	18	1	4822 075 00307	Meter, 350 mA	*
4	18	1	P4 670 50/AA	Correction screw	**
5	18	1	4822 216 00437	Push-button switch	*
6	18	1	4822 072 00093	Switch knob	
7	18	1	4822 044 00486	BNC connector BU2	*
8	18	4	P7 655 28	Rubber stud	**
9	18	1	M7 604 02	BNC connector BU1	*
10	18	1	4822 159 00366	Earthing socket BU3	*
11	18	1	4822 216 00423	Text plate	**
12	19	1	08 290 59	Mains plug	*
13	19	1	F101 AA/001	Fuse-holder	*
14	—	1	08 290 49	Female plug for item 12	*
15	19	1	A3 228 85	Voltage adapter	*
16	19	1	4822 157 00714	Slide switch	*
17	19	1	4822 216 00435	Battery compartment	*
18	11	1	4822 216 00436	Switch SK101	*
19	14	1	4822 216 00441	Print-plate U2	
20	15	1	4822 216 00442	Print-plate U3	
21	15	1	4822 216 00443	Print-plate U4	
22	14	1	4822 216 00444	print-plate U5	
23	20	1	4822 216 00445	Print-plate U6	
		10 cc	971/71	Switch oil	

Purpose of the column „S"

— *Components not marked*

They should be present at the Service Department in the country concerned or at the customer who is using the apparatus.
They include:
a. all electrical components;
b. mechanical parts which are vulnerable, or which are subject to wear.

— *Components marked with one star*

These components generally have a long or unlimited service-life, but their presence is essential for the correct working of the apparatus. Stocking up of a few of these components depends on the following factors:

a. the number of equipment present in the country concerned,
b. the necessity of having the apparatus working continuously or not,
c. the time of delivery of the components with respect to the import restrictions in the country concerned and the duration of the transport.

— *Components marked with two stars*

These components have a long or unlimited service-life and they are not essential for the correct working of the apparatus. Generally they are not stocked locally.

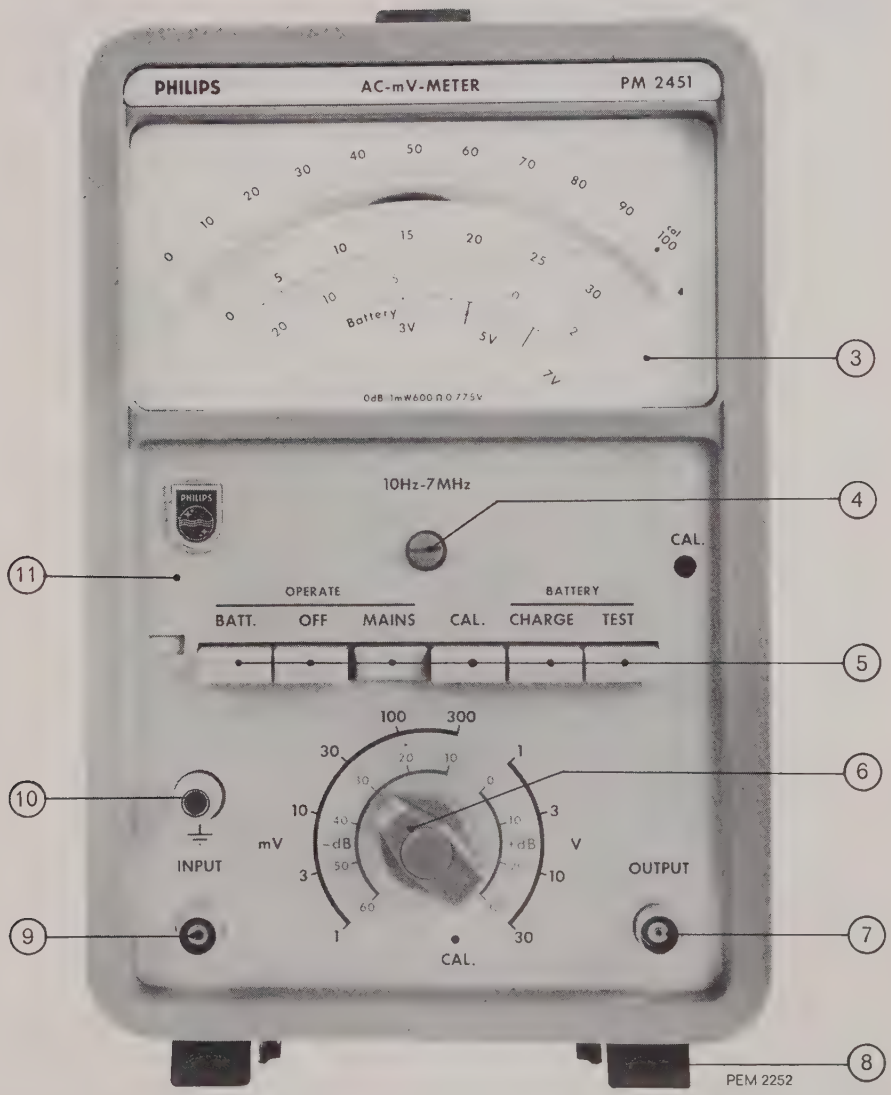


Fig. 18. Front view with item numbers

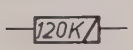
B. ELECTRICAL

No standard parts are included in this parts list with the exception of choice resistors.

The standard parts in the circuit diagram (Fig. 31) are indicated with symbols from which the service code number can be derived.
The key to the code is given below:

	Carbon resistor	0.25 W	≤ 1 MΩ : 5 % > 1 MΩ : 10 %	902/K...
	Carbon resistor	0.5 W	≤10 MΩ : 1 % >10 MΩ : 2 %	901/...
	Wire-wound resistor	0.4–1.8 W	0,5 %	901/W...
	Ceramic capacitor	500–700 V		904/...
	Styroflex capacitor	500 V	1 %	905/D...
	Polyester capacitor	400 V	10 %	906/...
	Ceramic trimmer (≤22E) Air trimmer (≥30E)			908/...

Example:



Code number 901/120K

Code number 904/4E7

The correct values of the choice-resistors and capacitors are determined during factory adjustment. All resistors are vaporized carbon resistors, unless otherwise specified.

Resistors

No.	*Code number*	*Value*	*Tolerance*	*Watts*	*Description*
R1	4822 071 00961	3.3 kΩ	5 %	3	Wire wound potentiometer
R101	4822 071 00909	990 kΩ	0.5%	1/4	Metal film
R102	4822 071 00771	10.1 kΩ	0.5%	1/8	Metal film
R103	4822 071 00911	713 Ω	0.5%	1/8	Metal film
R104	4822 071 00912	225 Ω	0.5%	1/8	Metal film
R105	4822 116 50169	71.3 Ω	0.5%	1/8	Metal film
R106	4822 116 50171	66.2 Ω	0.5%	1/8	Metal film
R107	4822 116 50172	54.1 Ω	0.5%	1/8	Metal film
R108	4822 116 50173	50 Ω	0.5%	1/8	Metal film
R109	4822 116 50173	50 Ω	0.5%	1/8	Metal film
R110	4822 116 50173	50 Ω	0.5%	1/8	Metal film
R111	4822 116 50173	50 Ω	0.5%	1/8	Metal film
R112	2x B8 305 23E/389E	194 Ω	1 %	1/8	Carbon (par.)
R114	2x B8 305 23E/410E	206 Ω	1 %	1/8	Carbon (par.)
R116	2x B8 305 23E/410E	206 Ω	1 %	1/8	Carbon (par.)
R117	901/1K1 + 901/150E	132 Ω	1 %	1/8	Carbon (par.)
R118	2x B8 305 23E/389E	194 Ω	1 %	1/8	Carbon (par.)
R120	2x B8 305 23E/410E	206 Ω	1 %	1/8	Carbon (par.)
R121	901/1K1 + 901/150E	132 Ω	1 %	1/8	Carbon (par.)
R123	901/18E 901/11E	6.8 Ω	10 %	1/4	Carbon (par.)
R204	902/K3K9-39K	3.9-39 kΩ	5 %	1/4	Choice resistor
R205	4822 071 00909	990 kΩ	0.5%	1/4	Metal film
R417	4822 071 00917	19.85 kΩ	0.5%	1/8	Metal film
R418	901/W585E	590 Ω	1 %	0.4	Wire wound
R422	902/K0-3K9	0-3.9 kΩ	5 %	1/4	Choice resistor
R425	4822 071 01017	130 Ω	10 %	1	NTC
R507	2x 901/W2K8	1400 Ω	1 %	0.4	Wire wound (par.)
R508	4822 071 00756	43 kΩ	1 %	1/8	Metal film
R515	901/W0-1K	0-955 Ω	1 %	0.4	Choice resistor
R516	901/W12-15K	13-15 kΩ	1 %	1.2	Choice resistor

No.	*Code number*	*Value*	*Tolerance*	*Watts*	*Description*
R521	2x 901/11E	5.6 Ω	10 %	1/4	Carbon (par.)
R525	E104 AA/AE 33	0.33 Ω	10 %	2	Load resistor
R601	938/A12E	12 Ω	5 %	5.5	Wire wound
R602	2x 938/A18E	36 Ω	5 %	10	Wire wound (series)

Capacitors

No.	*Code number*	*Value*	*Tolerance*	*Volts*	*Description*
C102	C 005 AA/10E	10 pF		500	Air trimmer
C203	909/Z20	20 µF		6.4	Electrolytic
C205	909/W250	250 µF		16	Electrolytic
C206	4822 069 00669	320 µF		6.4	Electrolytic
C301	909/C100	100 µF		10	Electrolytic
C302	909/C6.4	6.4 µF		25	Electrolytic
C303	905/D5E	5.1 pF	± 0,5 pF	500	Styroflex
C304	909/U200	200 µF		10	Electrolytic
C305	4822 069 01105	0.1 µF	10 %	250	Plate
C307	905/D5E	5.1 pF	± 0.5 pF	500	Styroflex
C308	4822 069 00675	1000 µF		4	Electrolytic
C309	4822 069 00622	1 µF	10 %	250	Polyester
C310	4822 069 01087	0.022 µF	10 %	250	Plate
C311	C 010 AA/60E	60 pF		300	Trimmer
C313	909/T640	640 µF		10	Electrolytic
C314	4822 069 00682	0.47 µF	10 %	250	Polyester
C315	4822 069 01102	0.056 µF	10 %	250	Plate
C401	4822 069 00881	22 µF		15	Electrolytic
C402	909/T250	250 µF		4	Electrolytic
C403	4822 069 01105	0.1 µF	10 %	250	Plate
C406	C 010 AA/60E	60 pF		300	Trimmer
C407	909/T250	250 µF		4	Electrolytic
C408	4822 069 01123	0.22 µF	10 %	250	Polyester
C409	909/U200	200 µF		6.4	Electrolytic
C411	909/W125	125 µF		6.4	Electrolytic
C412	909/W125	125 µF		6.4	Electrolytic
C413	4822 069 01105	0.1 µF		250	Plate
C414	909/U32	32 µF		10	Electrolytic

No.	*Code number*	*Value*	*Tolerance*	*Volts*	*Description*
C415	4822 069 00682	0.47 µF	10 %	250	Polyester
C501	4822 069 01105	0.1 µF	10 %	250	Plate
C502	4822 069 00622	1 µF	10 %	250	Polyester
C504	909/U16	16 µF		10	Electrolytic
C505	909/U16	16 µF		10	Electrolytic
C507	4822 069 01087	0.022 µF	10 %	250	Plate
C508	909/W250	250 µF		16	Electrolytic
C509	4822 069 00682	0.47 µF	10 %	250	Polyester
C510	909/X64	64 µF		16	Electrolytic
C511	909/W250	250 µF		10	Electrolytic
C512	909/W250	250 µF		16	Electrolytic
C601	C 430 BL/F800	800 µF		25	Electrolytic

Miscellaneous

L101	4822 128 00556	Coil, 0.68 µH
L301	4822 128 00562	Coil, 33 µH
L302	4822 128 00563	Coil, 27 µH
L401	4822 157 20099	Coil, 6.8 µH
L501	4822 128 00463	Coil, 120 µH
T1	4822 216 00438	Supply transformer
T501	4822 216 00439	Transformer
T502	4822 216 00401	Transformer
VL1	974/V63	Fuse, 63 mA (delayed action)

Transistors and diodes

TS201	4822 128 00438	Field effect transistor
TS202	AF121	Germanium transistor
TS301	BC107	Silicon transistor
TS302	AF185	Germanium transistor
TS303	AF121	Germanium transistor
TS304	AF121	Germanium transistor
TS305	BSY39	Silicon transistor
TS401	AF121	Germanium transistor
TS402	AF121	Germanium transistor
TS403	AF121	Germanium transistor

TS404	BSY39	Silicon transistor
TS501	AF185	Germanium transistor
TS502	BCZ11	Silicon transistor
TS503	AF126	Germanium transistor
TS504	ASY29	Germanium transistor
TS505	BCY34	Silicon transistor
TS506	AD139	Germanium transistor
GR1	BZZ14	Zener diode
GR2	BZZ17	Zener diode
GR201	BAY38	Silicon diode
GR202	BAY38	Silicon diode
GR203	OA73	Germanium diode
GR301	BZY60	Silicon diode
GR401	OA90	Germanium diode
GR402	OA90	Germanium diode
GR403	OA200	Silicon diode
GR404	AAY21	Germanium diode
GR501	OA85	Germanium diode
GR502	OA200	Silicon diode
GR503	BZY61	Zener diode
GR504	BAY32	Silicon diode
GR505	BZY59	Zener diode
GR506	BZY58	Zener diode
GR507	AAZ12	Germanium diode
GR508	AAZ12	Germanium diode
GR601	BY100	Silicon diode
GR602	BY100	Silicon diode

Apart from the field effect transistor TS201, which is delivered by Central Service, all transistors and diodes are delivered by the Marketing Dep't "Electronica".

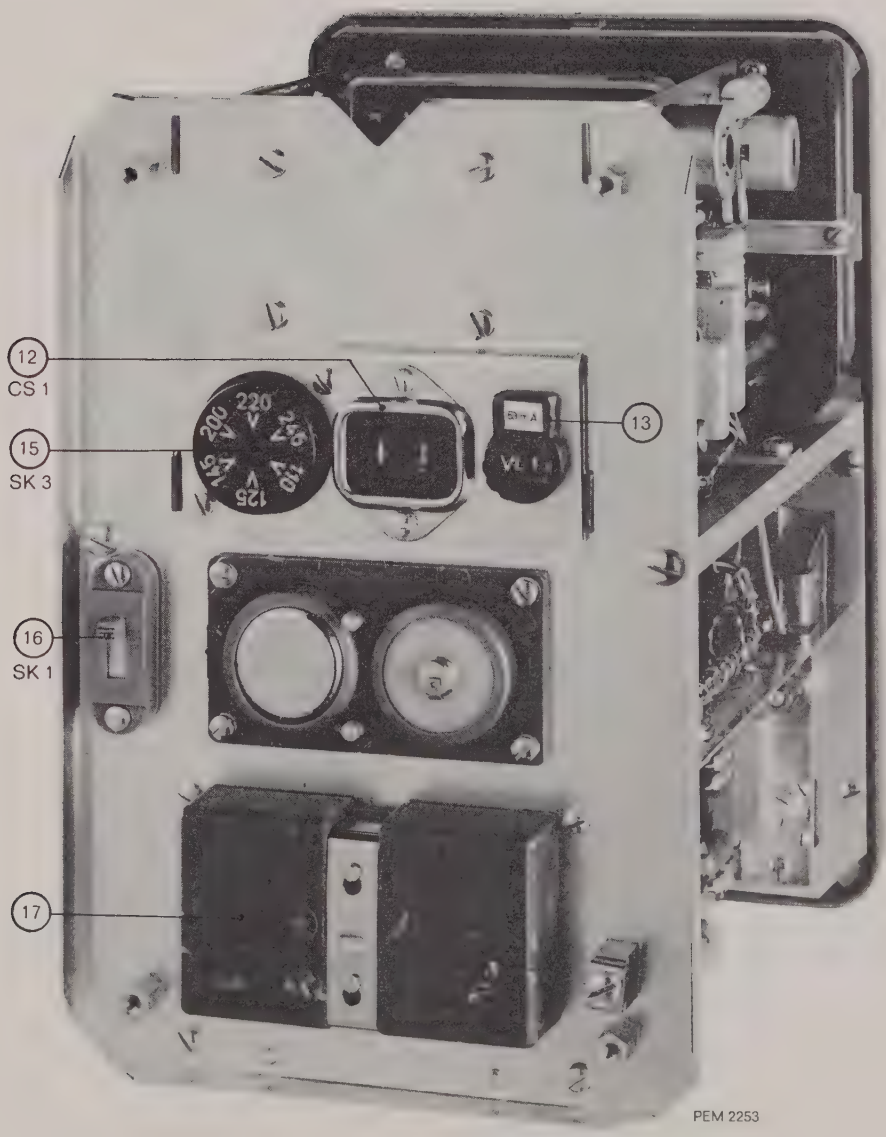


Fig. 19. Interior view from the rear

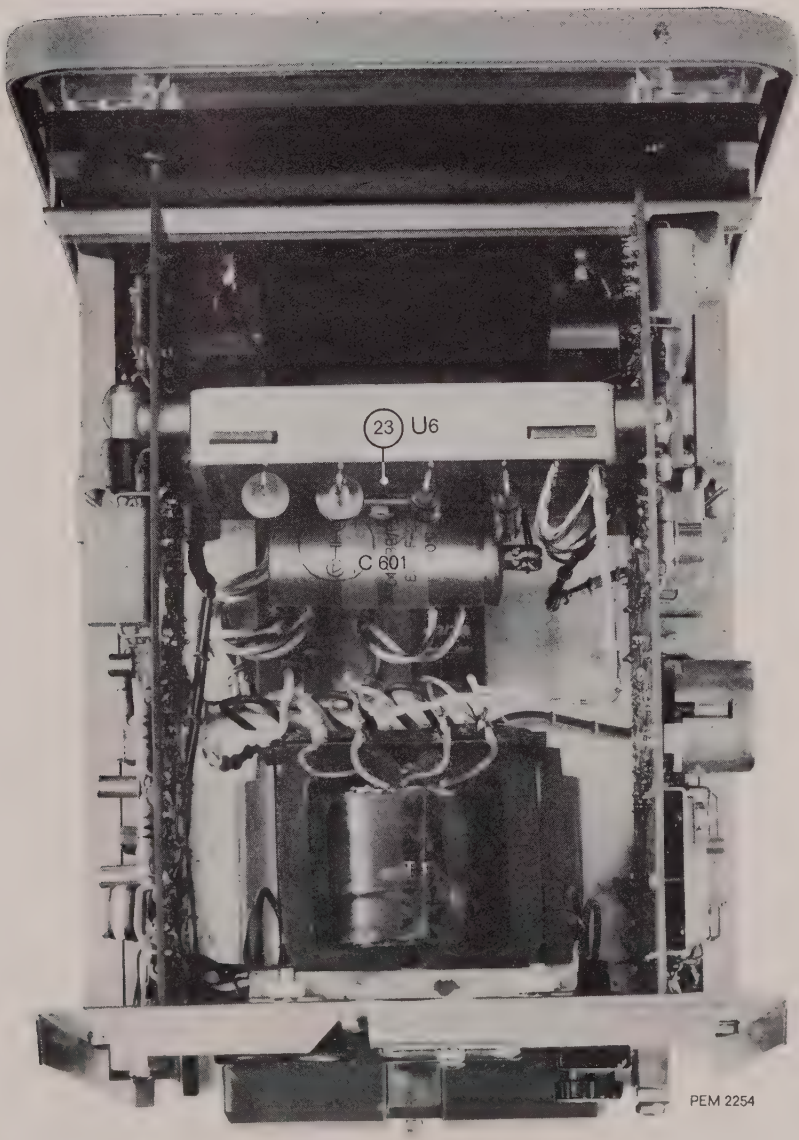


Fig. 20. Top view

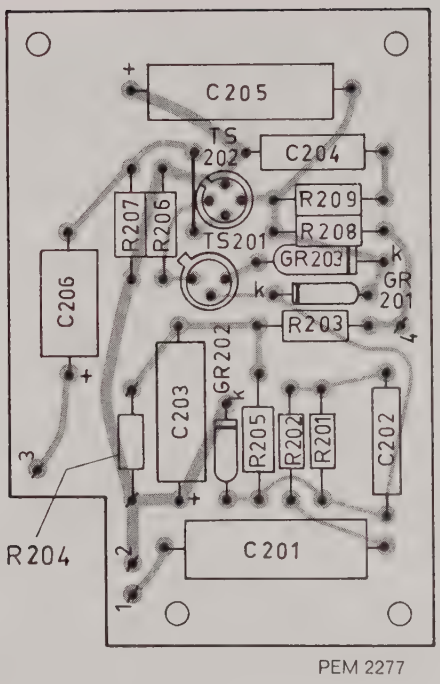


Fig. 21. Print-plate U2

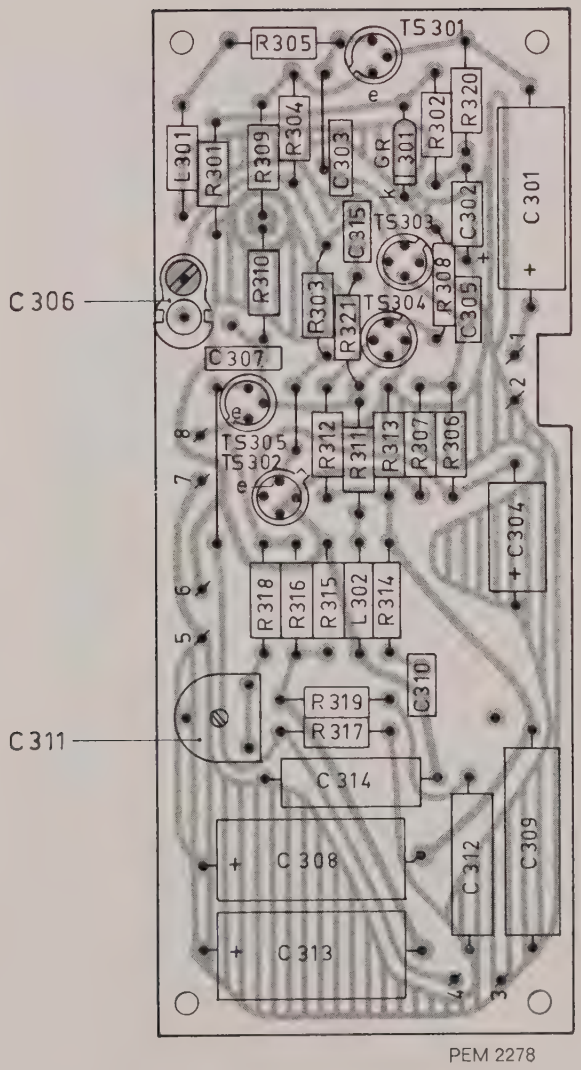


Fig. 22. Print-plate U3

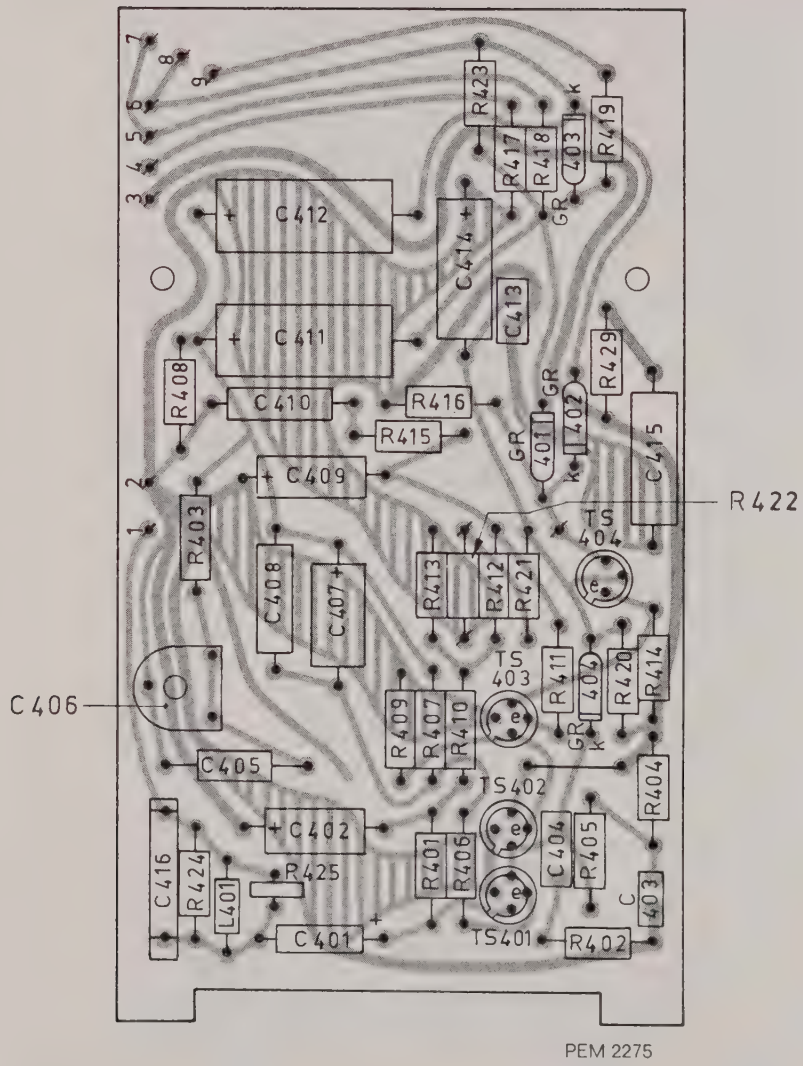


Fig. 23. Print-plate U4

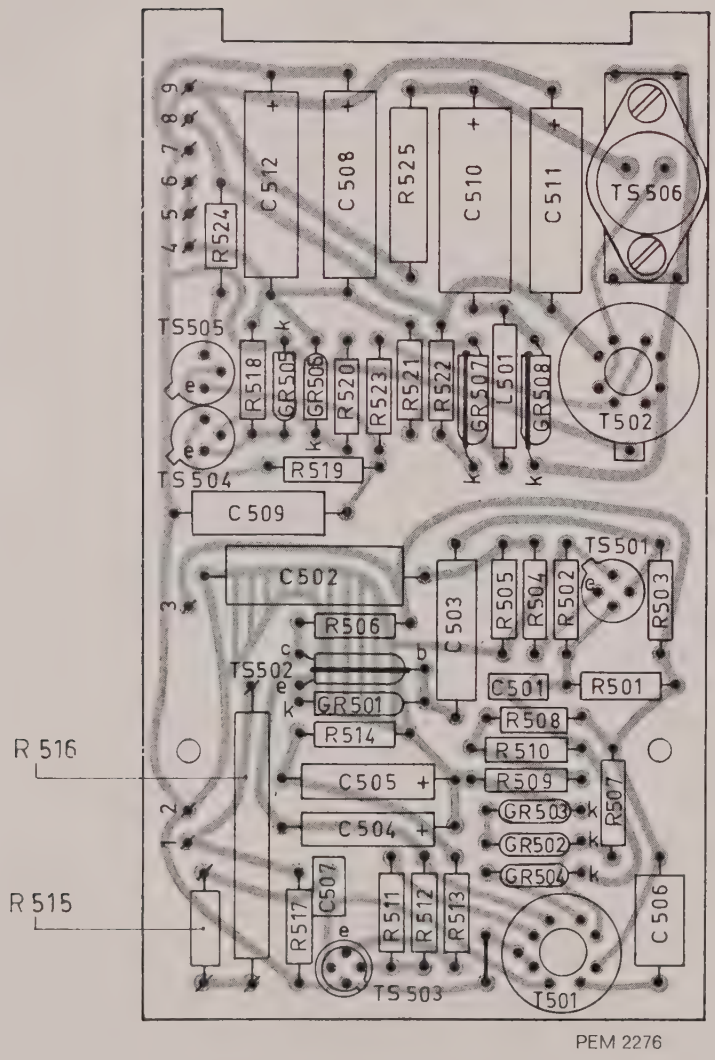


Fig. 24. Print-plate U5

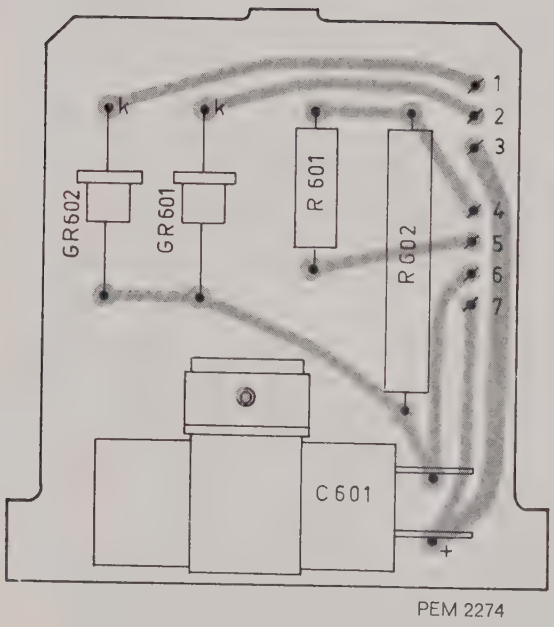


Fig. 25. Print-plate U6

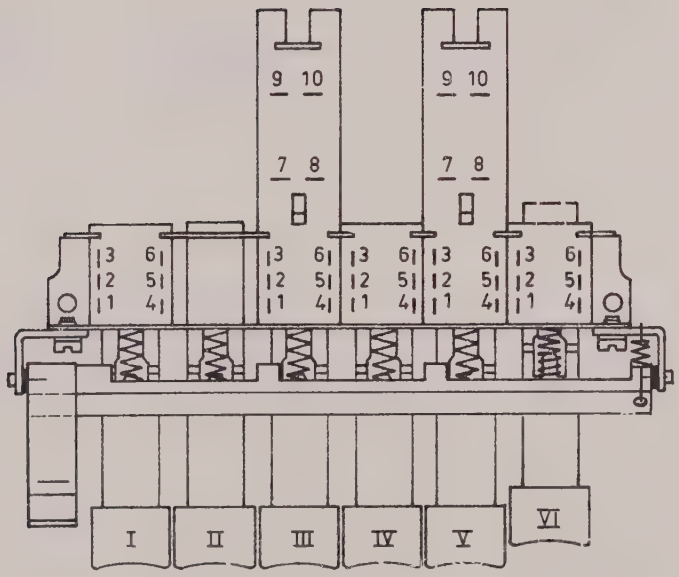
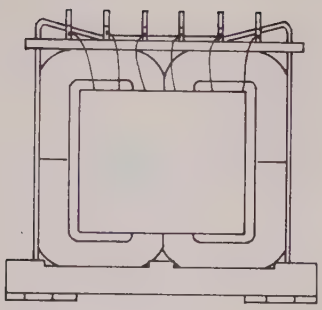
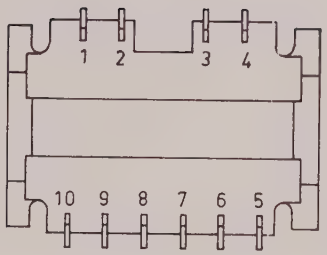
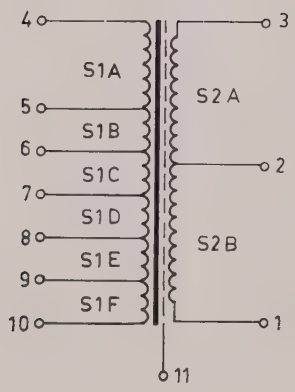


Fig. 26. Push-button switch SK2

Fig. 27. Switch SK101



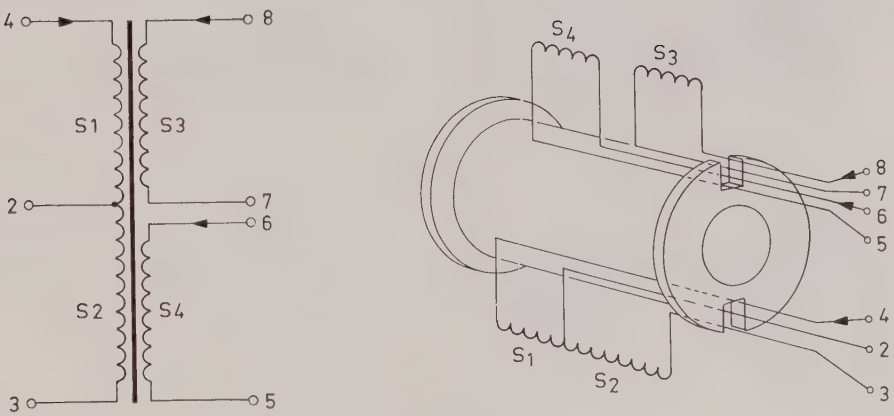




CODE	S1A	S1B	S1C	S1D	S1E	S1F	S2A	S2B
TURNS	1305½	190	225	660	240	300	224	224

PEM 2279

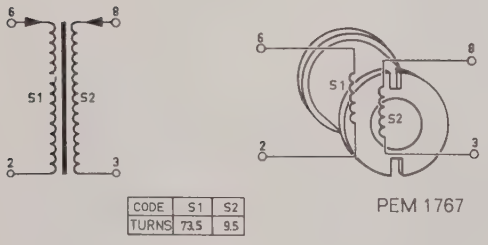
Fig. 28. Transformer T1



CODE	S1	S2	S3	S4
TURNS	74	209	1	137

PEM 2280

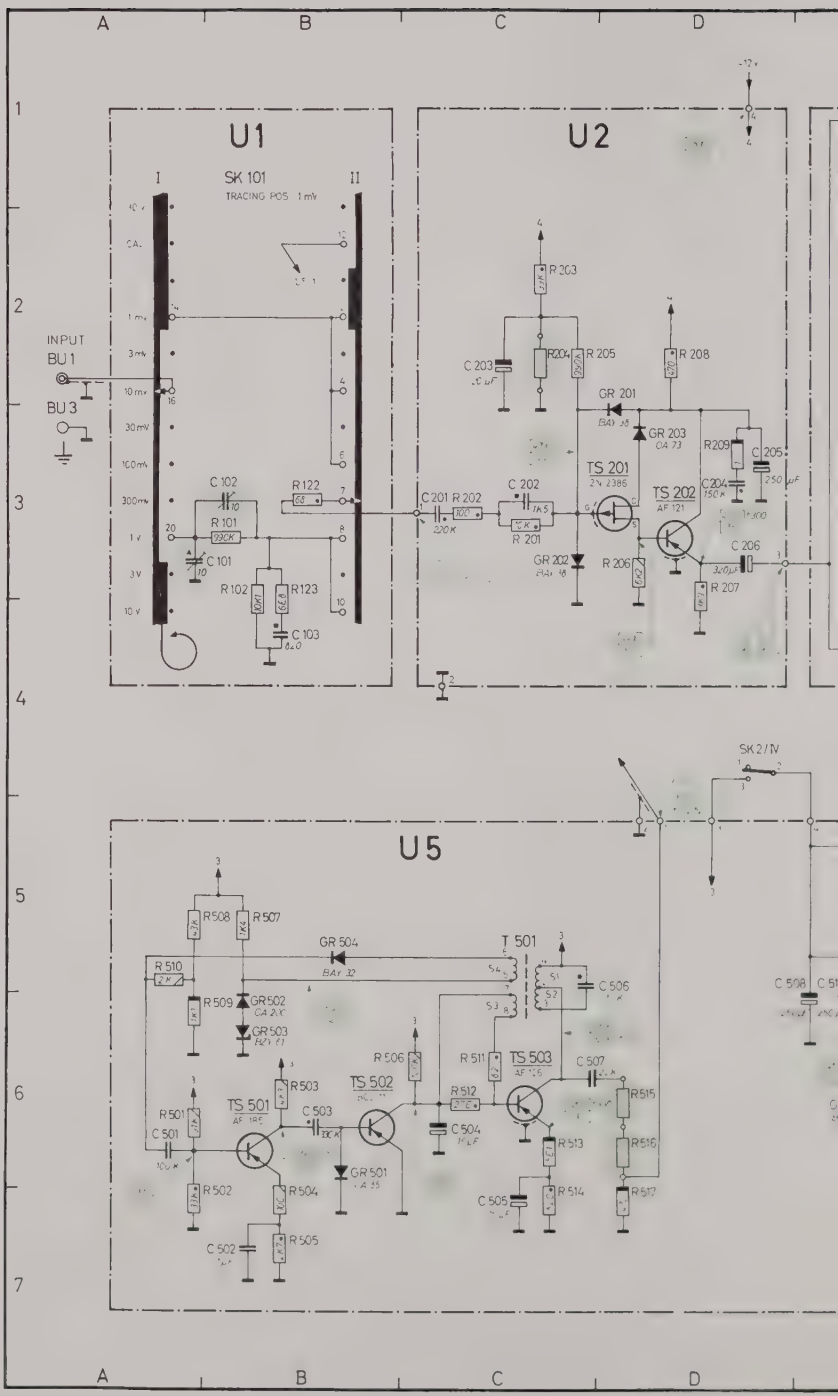
Fig. 29. Transformer T501

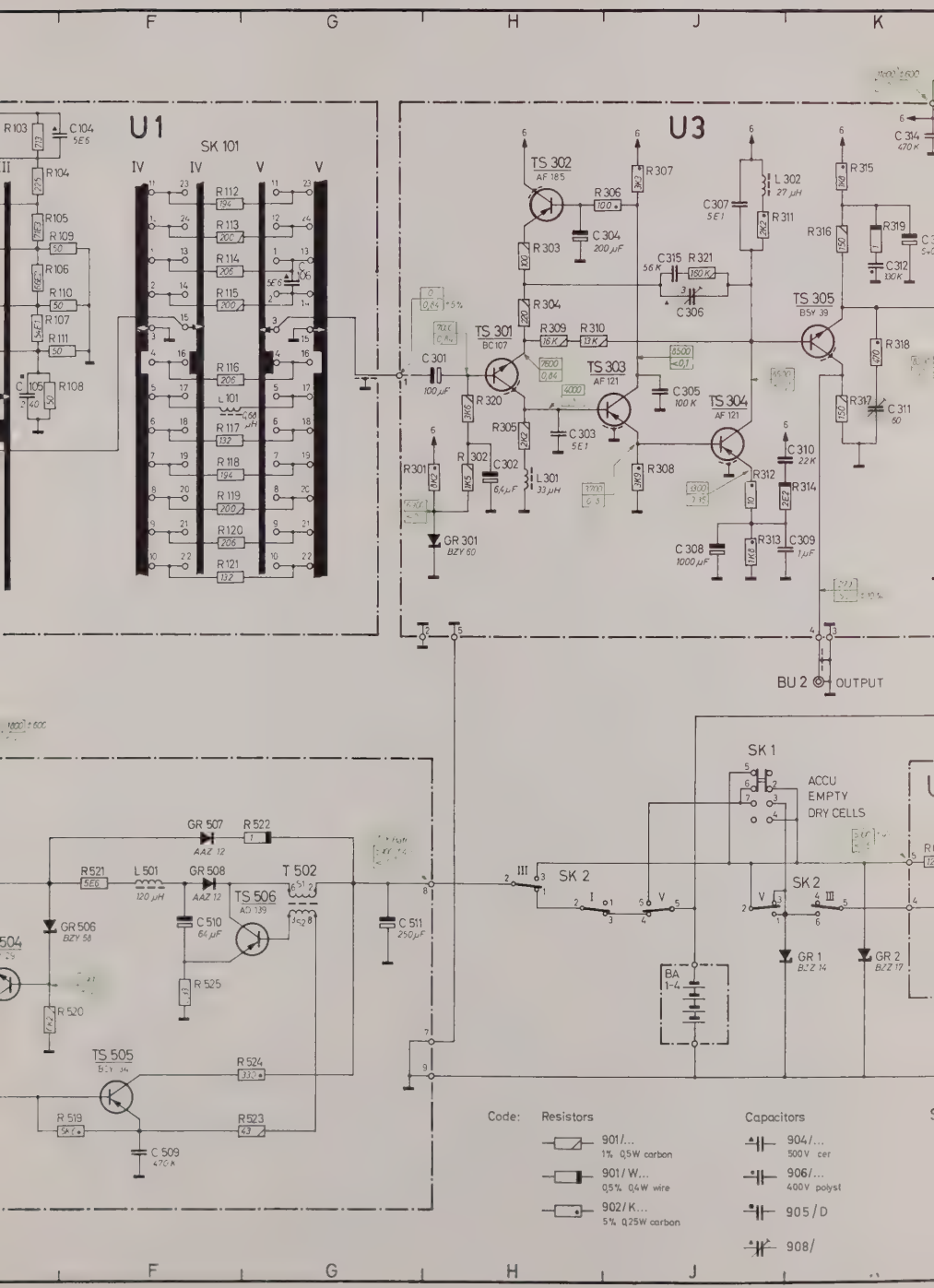


CODE	S1	S2
TURNS	73.5	9.5

PEM 1767

Fig. 30. Transformer T502


A
B
C
D
1
2
3
4
5
6
7
U1
U2
U5
SK 101
TRACING POS 1 mV
I
II
INPUT
BU 1
BU 3
C 102
R 122
C 101
R 101
R 102
R 123
C 103
C 201
R 202
C 202
R 201
R 203
R 204
R 205
R 208
C 203
GR 201
GR 203
TS 201
TS 202
R 209
C 205
C 204
C 206
R 207
GR 202
R 206
SK 2/IV
T 501
GR 504
R 508
R 507
R 510
R 509
GR 502
GR 503
R 506
R 511
TS 503
C 507
C 506
R 503
TS 502
R 512
C 504
R 515
R 516
R 513
R 514
R 517
C 505
TS 501
C 503
R 501
C 501
R 502
R 504
GR 501
C 502
R 505


F
G
H
J
K
U1
SK 101
U3
TS 302
AF 185
TS 301
BC 107
TS 303
AF 121
TS 304
AF 121
TS 305
BSY 39
GR 301
BZY 60
BU 2
OUTPUT
SK 1
ACCU
EMPTY
DRY CELLS
SK 2
GR 507
AAZ 12
GR 508
AAZ 12
T 502
TS 506
AD 139
GR 506
BZY 58
TS 505
BCY 34
GR 1
BZZ 14
GR 2
BZZ 17
BA
1-4
Code:
Resistors
901/...
1% 0,5W carbon
901/W...
0,5% 0,4W wire
902/K...
5% 0,25W carbon
Capacitors
904/...
500V cer
906/...
400V polyst
905/D
908/

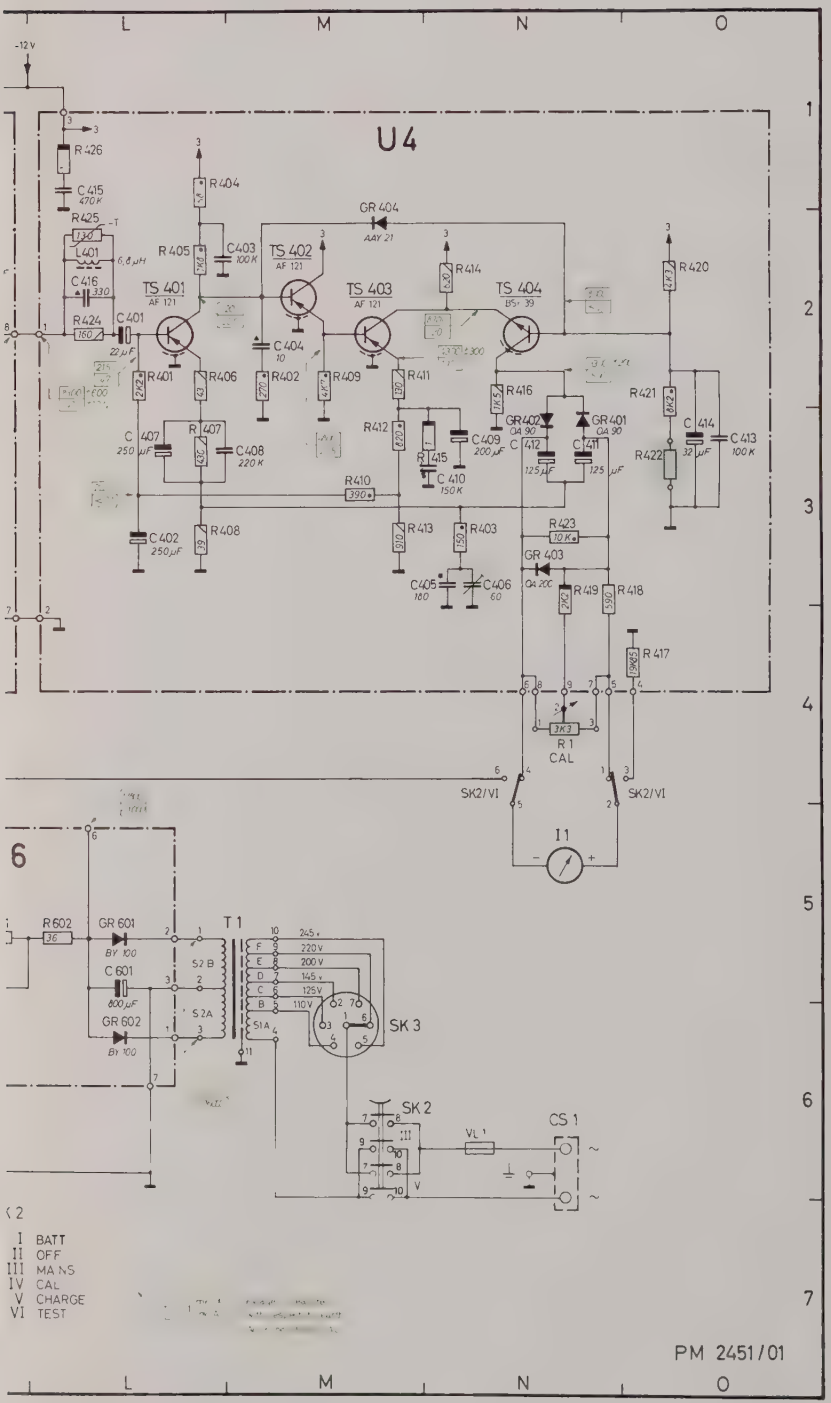


Fig. 31. Circuit diagram, PM 2451

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